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# THE MID-SUMMER BIRD LIFE OF ILLINOIS: A STATISTICAL STUDY[1]

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IN the course of a statistical survey of the bird population of the State of Illinois, begun with a view to a better knowledge of the significance of birds in the economy of nature, two field observers, A. O. Gross and H. A. Ray, engaged in this work as assistants on the State Natural History Survey, spent virtually a month of the summer period of 1907 in each of the three principal sections of the state—June in southern, July in central, and August in northern, Illinois. Selecting in each section a locality typical for that part of the state, they made regular trips on foot in various directions and to various distances, traveling always thirty yards apart, and noting as they went the species and numbers of all birds flushed by them on a strip fifty yards in width, including likewise those flying across this strip within a hundred yards to their front. They kept record, also, by means of mechanical counters, of the distances traveled over each distinguishable kind of area, commonly marked by the crop which is borne.

The present paper is a report of a few of the more general results of a study of the materials thus brought together, illustrating the numbers and ecological distribu-

[1] Read before the Central Branch of the American Society of Zoologists, Chicago, January 2, 1908.

tion of the birds of Illinois during the relatively stable period of their summer residence—the time between the conclusion of the spring migration and the beginning of the fall movement to the southward. It is a period of breeding and steady habitation for our most permanent and characteristic bird population, and will best help us to an understanding of the main normal ecological significance of Illinois birds.

### THE AREA OF OBSERVATION

The total distance traveled by my observers on these various mid-summer trips was 428 miles (omitting fractions), of which 141 miles was in southern Illinois, 112 in central, and 175 in northern. The total area covered by this strict census of the bird population was a trifle over 12 square miles, or 7,693.5 acres—33 per cent. of this acreage being in the southern, 26 per cent. in the central, and 41 per cent. in the northern, part of the state—or approximately a third of this area in southern, a fourth in central, and two fifths in northern, Illinois. The field observations began in the south June 4, and ended at the north August 23, with the idea of avoiding, so far as possible, by this order of progress, differences due to different seasonal conditions. It was not possible, of course, to eliminate these wholly, with only one pair of observers; and it will tax our ingenuity, and sometimes perhaps overtax it, to detect these differences and to distinguish them from those due to mere difference of latitude and of climate corresponding.

The total surface on which these precise mid-summer observations were made was 1/4,720 part of the whole state, and the question at once arises, Was this area sufficient to give these results any general value for the state at large, and, if so, how may we be sure of it? There is, I believe, no mathematical method of determining the sufficiency of these data for generalization purposes, and I know of no test at present applicable except that of the general consistency and reasonableness of the totals,

averages and ratios, for the different districts and seasons, the presence or absence of which each can readily see for himself as this discussion proceeds. If the data of observation are insufficient for the uses made of them, there will be a random variability and inexplicable irregularity in my statistical summaries which we shall not fail to notice.

### General Product of the Survey

Gross and Ray identified during the summer, on the territory covered by their data, 7,740 birds, belonging to 85 species. This is at the rate of 645 birds per square mile, or almost precisely 1 per acre, including the so-called English sparrow. If we omit the 1,414 interloping English sparrows observed—which is a little more than 18 per cent. of the entire number of birds—we have remaining 527 *native* birds to the square mile. The total for Illinois,[2] on this basis, is 30,750,000 native birds and 5,536,000 English sparrows, or approximately 14 summer resident birds to each person in this state living in the country or in towns of less than 25,000 inhabitants.

Of the 85 species represented by the 7,740 birds recognized on these trips, the 21 most abundant species were represented by 6,596 birds. That is to say, 85 per cent. of the birds belonged to 25 per cent. of the species. The 21 more abundant species numbered, taken together, 550 to the square mile, and the 64 less abundant species, taken together, numbered 95 birds to the square mile, or 1 to every $6\frac{3}{4}$ acres. The latter species are evidently negligible as general factors in the ecological system, and attention need be given, in discussing the birds of the state as a whole, only to the 21 species common enough to produce some appreciable general effect. Given in the order of their abundance they are as follows:

[2] A combination of the averages for the three sections of the state, computed separately, the data for the sections being differently weighted to compensate for differences in area.

| A. O. U. Nos. | Bird | No. Observed | Per Cent. |
|---|---|---|---|
| X | English sparrow | 1,414 | 18.4 |
| 501 | Meadow-lark | 1,025 | 13.2 |
| 511b | Bronzed grackle | 900 | 11.6 |
| 316 | Mourning-dove | 461 | 6. |
| 604 | Dickcissel | 393 | 5.1 |
| 498 | Red-winged blackbird | 347 | 4.4 |
| 474b | Prairie horned lark | 296 | 3.8 |
| 412 | Flicker | 197 | 2.6 |
| 761 | Robin | 194 | 2.5 |
| 563 | Field-sparrow | 186 | 2.4 |
| 529 | American goldfinch | 158 | 2. |
| 444 | Kingbird | 126 | 1.8 |
| 494 | Bobolink | 119 | 1.5 |
| 546 | Grasshopper sparrow | 110 | 1.4 |
| 705 | Brown thrasher | 104 | 1.3 |
| 495 | Cowbird | 102 | 1.3 |
| 406 | Red-headed woodpecker | 99 | 1.3 |
| 613 | Barn-swallow | 96 | 1.2 |
| 289 | Quail | 91 | 1.2 |
| 261 | Bartramian sandpiper | 89 | 1.1 |
| 488 | Crow | 89 | 1.1 |
| | | 6,596 | 85.2 |

## VARIATION WITH LATITUDE

The English sparrow decreases in abundance from north to south, from 147 to the square mile in northern to 113 in central, and 82 in southern, Illinois. One hundred sparrows in the northern part of the state are thus represented by 77 in the central and 56 in the southern part.[3] The *native* summer residents, on the other hand, increase in numbers from north to south, the birds per square mile being 464, 537 and 600 for nothern, central and southern Illinois, respectively. That is, 100 native birds in northern Illinois were represented in mid-summer by 116 in central and 129 in southern Illinois. The decrease in English sparrows from north to south is not sufficient to offset the increase in the native species, the total numbers per square mile for all summer birds in the three sections of the state being 610, 650 and 682—or 100 birds in northern for 107 in central and 112 in southern Illinois.

This same gradation was much more pronounced in the record of the *winter* residents. From the last of Novem-

[3] Since the above was written, my attention has been called, by Dr. Hans Gadow, to the fact that in Europe also this sparrow diminishes in number southward.

ber to March 15, birds averaged 384 to the square mile in northern Illinois; from December 23 to March 21, 582 to the mile in central Illinois; and from February 6 to February 21, 832 to the mile in southern Illinois, numbers related to each other as 100, 151 and 217. Indeed, we find birds more abundant in extreme southern Illinois in the mid-winter period of 1906–07 than in the mid-summer period of 1907, averaging at the rate of 122 birds in the former season to each hundred in the latter.

If we take into account the numbers for the whole year, there are, for every hundred birds in the northern part of the state, 133 for central and 181 for southern Illinois.

BIRDS BY SECTIONS

| | Northern Illinois | Central Illinois | Southern Illinois |
|---|---|---|---|
| Summer: | | | |
| Native | 100 | 116 | 129 |
| Sparrows | 100 | 77 | 56 |
| All birds | 100 | 107 | 112 |
| Winter: | | | |
| Native | 100 | 170 | 292 |
| Sparrows | 100 | 65 | 1 |
| All birds | 100 | 151 | 217 |
| Whole year: | | | |
| All birds | 100 | 133 | 181 |

The bobolink was a distinctively northern bird, occurring in the ratio of 24 to the square mile in northern Illinois, and not at all in either of the other sections. The mocking-bird, on the other hand, was almost exclusively southern, being represented by 8 birds to the square mile in the southern section, by only 1 specimen seen in central Illinois, and not at all in the northern part of the state.

## MIGRATION WAVES

In a paper published last April under the title "An Ornithological Cross-section of Illinois in Autumn,"[4] I gave the data and results of a trip across central Illinois made by Gross and Ray during the fall of 1906. A comparison of the general average of the bird population,

[4] Bull. Ill. State Lab. Nat. Hist., Vol. VII, art. 9.

determined from the data of this trip for the period of the fall migrations, with the mid-summer average for the same section of the state, as determined last July, shows an interesting difference which leads us to consider the effect of the autumnal movement to the south on the numbers of the local bird population. On the above trip across the state, made between August 28 and October 17, 1906, a general average of 579 native birds to the square mile was found, while the corresponding mid-summer average for the present year is 537 native birds to the square mile—a difference of 42 birds to the mile, or nearly 8 per cent., in favor of the fall population.

NATIVE BIRDS PER SQUARE MILE, FALL (1906), SUMMER (1907)

| | Migrant | Resident | Total |
|---|---|---|---|
| Summer | | 537 | 537 |
| Fall | 98 | 481 | 579 |
| Difference | +98 | −56 | +42 |

Was this difference due to the fact that the fall migration was in progress when last year's observations were made? That is, does the migration movement begin first at the north and result in a local wave of increased numbers, birds coming in from the north earlier and faster than the resident species leave for the south? It is possible to answer this question by reference to the data of the paper just cited.

An analysis of the list of species identified on last year's autumnal trip shows that 481 per square mile of these birds were summer residents, still remaining, and that 98 per square mile belonged to migrant species, on their way to the south. The summer residents still present in this autumnal period were thus 56 per square mile fewer than the resident birds of the present summer. That is, 56 summer residents for each square mile of central Illinois had gone south, on an average, and 98 fall migrants had, on the other hand, come in to take their place, the difference between these numbers giving us

the excess of 42 birds per square mile of fall over summer. This temporary increase of 8 per cent. in autumn in the average number of our birds is thus evidence of a wave of condensation running southward in consequence of the earlier beginning and more rapid development at the north of the annual fall migration.

This contrast of the number of the resident summer population with that of the fall migration period is still more clearly and strongly shown by a comparison of the totals of all our central Illinois observations in mid-summer and in fall, respectively. These average 1.07 birds to the acre for the period from July 9 to September 21, and 2.31 per acre for the interval between the 1st and the 26th of October. That is, more than twice as many birds per acre were seen in October of this year as in July, August and September.

The data of the *spring* migration of 1907 are unsatisfactory owing to the extraordinary character of the season, and the consequent repeated interruption and remarkable prolongation of the movement. Nevertheless, they indicate a larger population during the early part, at least, of this migration period also than either before or after it. A trip down the eastern side of the state from Cook to White county, begun March 26 and ending April 11, gave an average of 1.34 birds to the acre—a number to be compared with our mid-summer average for the whole state, which is 1.03. That is, the average early spring population of this exceptional year was 30 per cent. greater than the average of the summer following. On the other hand, a trip across central Illinois between April 20 and May 29, still within the migration period, gave us, for 5 1/3 square miles of area, an average of only .89 per acre—less than even the mid-winter average of .91 for the same part of the state.

## Vegetation of the Inspection Area

As a basis for a more precise account of the distribution of birds as a whole and of the more important

species, it will be necessary to consider the vegetable covering of the soil, since there is little else in Illinois by which different portions of its area may be distinguished. The territory traversed by my observers, it need hardly be said, was almost wholly under cultivation. Excluding only forests in which the trees were too high, or the undergrowth was too dense, to permit a full and accurate census of the birds, the territory reported upon was chosen wholly at random, and the total for each division of the state seems sufficient to give us, with the exception just mentioned, a fair sample of its crops and surface conditions. The areas from which all the birds were determined were 3,172 acres for northern Illinois, 2,117 acres for central, and 2,504 acres for southern.

In the upper third of the state, 95 per cent. of the surface was in corn, small grain and grass—31 per cent. in corn, 27 per cent. in small grain (nearly all of it oats) and 37 per cent. in the pasture and meadow crops, about equally in each. In the central region the area in corn rises to 46 per cent. of the whole, that in small grains was about 26 per cent. (again nearly all oats) and that in the forage crops was 27 per cent. (the pasture lands nearly twice as extensive as the meadows)—a total of 99 per cent. of the area examined which was devoted to these great farm crops. In the lower third of Illinois only 23 per cent. of the land was in corn, an almost equal area (21 per cent.) was in small grain—more than half of it wheat—and 44 per cent. was in grass, clover and similar forage plants, rather equally divided between pastures and meadows. That is to say, the areas in corn and small grains were nearly the same, and these together were barely equal to the meadows and pastures. The

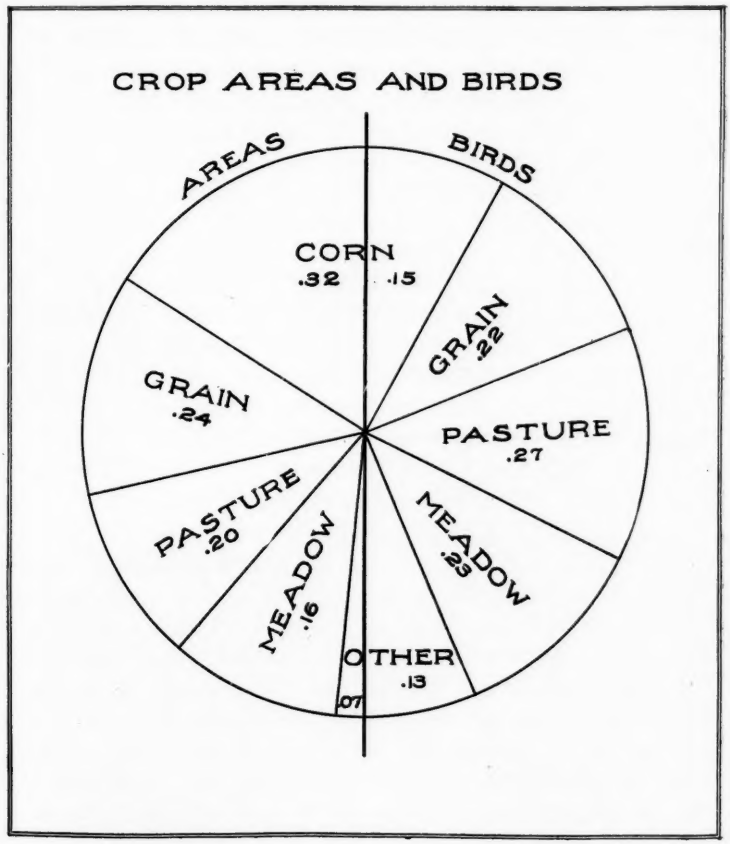
CROP AREAS. PER CENT., 1907

| | Northern Illinois | Central Illinois | Southern Illinois |
|---|---|---|---|
| Corn | 31 | 46 | 23 |
| Grain | 27 | 26 | 21 |
| Grass | 37 | 27 | 44 |
| Miscellaneous | 5 | 1 | 12 |

total in all these crops was 88 per cent. of the area inspected, the remaining 12 per cent. covering the orchards, the more open woods, the waste and untilled lands, and a few additional minor items.

### Numbers of Birds by Crops

Illinois is still a prairie state in the predominance of birds which prefer a grassy turf as an abiding place.




Almost exactly half of those recorded for the state last summer were from pastures and meadows, although the

total acreage in these lands was but 36 per cent. of the entire area inspected. These figures are equivalent to a density ratio on pastures and meadows of 1.39 for all the birds of the state.[5] Corn is an exotic crop in Illinois, and birds were only about a third as abundant in corn fields as in grass lands, while in small grains they were nearly twice as abundant as in corn. The acreage in these crops was such that 15 per cent. of all the birds of the season were found in corn fields and 22 per cent. were in small grain. In orchards they averaged 4½ times as numerous to the unit of area as in fields of grain, 2,471 to the square mile—giving a density ratio of 3.84; but the acreage in orchards from which the birds were identified was so small that all the orchard birds together amount to only 2 per cent. of the whole number observed. Among native trees and shrubbery, birds were much less abundant than among fruit trees, and the density ratio for these situations was about 2.25.

By way of further illustration of the application of this quantitative method to the subject of local distribution, I will present some of the more pronounced results for one species of bird throughout its range in summer, and for one kind of crop area as visited or inhabited by midsummer birds.

### THE MEADOW-LARK

One thousand and twenty-five meadow-larks were identified by my observers in their work on the summer residents of the state, an average of 85 to the square mile for the whole area traversed by them. As these birds were unequally distributed, never occurring, for example, in woodlands or among shrubbery, their numbers rose in some situations far above this general average, amounting to 266 to the square mile in stubble, 205 in meadows, 160 on untilled lands, 143.5 in pastures, and 131 on waste lands, and falling to 10 to the square mile in fields of corn.

[5] That is, taking an average density of the bird population for the whole area of the state as 1, the density in pastures and meadows only is 1.39.

MEADOW-LARKS PER SQUARE MILE. SUMMER, 1907

| | |
|---|---|
| Stubble | 266 |
| Meadows | 205 |
| Fallow | 160 |
| Pastures | 143.5 |
| Waste | 131 |
| Corn | 10 |
| Woods | — |
| Shrubs | — |
| State | 85 |

They varied also in abundance, in a very interesting way, from the north to the south. One hundred of them in northern Illinois were represented by 175 in central and by 215 in southern Illinois. This variation was evidently independent of any difference in the extent of surface covered by the kinds of vegetation which they most prefer, since the ratio of pasture, meadow, waste and untilled lands taken together was considerably less for central than for northern Illinois, although the meadow-larks were 75 per cent. more numerous; and it was only a fourth greater for southern Illinois than for northern, although the meadow-larks were more than twice as abundant. The cause of the greater numbers southward, so far as I can see, can be accounted for only rather vaguely as climatic.

Much more difficult of even general or hypothetical explanation is a curious difference in the observed abundance of meadow-larks in pastures and meadows respectively, in the three divisions of the state. In northern Illinois there were 87 larks per square mile in pastures to 129 in meadows; in southern Illinois there were 125 in pastures to 297 in meadows; while in central Illinois this relation was reversed, the number in pastures being 274 to the mile, and that in meadows 189. That is, while 100 pasture birds were represented in northern Illinois by 148 in meadows, and in southern Illinois by 242, in central Illinois they were represented by only 69. Since the southern Illinois observations were made in June, those for central Illinois in July and those for northern

Illinois in August, one naturally looks to differences in season, in the advancement of the crops, or in agricultural operations as related to the haunts and habits of these birds, for an explanation of their apparent shift from meadows to pastures in July in central Illinois, and a seemingly plausible explanation is suggested by the fact that haying was mainly done during July in the central part of the state, but was not yet fairly begun in southern Illinois in June and was nearly over in northern Illinois in August.

PASTURE BIRDS PER SQUARE MILE. SUMMER, 1907

*Meadow-larks*

| | Northern Illinois | Central Illinois | Southern Illinois |
|---|---|---|---|
| Pasture | 87 | 274 | 125 |
| Meadow | 129 | 189 | 297 |
| *Other Pasture Birds* | | | |
| Pasture | 50 | 54 | 120 |
| Meadow | 200 | 131 | 371 |

If, however, the meadow-larks were disturbed to this extent by the operations of making and saving the hay crop, one would expect to find the other distinctively meadow birds similarly affected—a supposition which is not borne out by the facts of our record. Besides the meadow-larks, there were five common species more abundant in meadows in one or another section of the state than in any other important situation; namely, the red-winged blackbird, the purple grackle, the vesper-sparrow, the grasshopper sparrow, and the dickcissel. Each of these species was, moreover, more abundant in meadows than in pastures in each section of the state—in central Illinois as well as in the other two—excepting only the grackle in southern Illinois. Taking all five of these birds together, there were in northern Illinois 200 to the square mile in meadows and 50 in pastures, in central Illinois 131 and 54, respectively, and in southern Illinois 371 and 120. In other words, for each hundred of these

five kinds of birds in meadows, there were, in the northern section, 25 of them in pastures, in the central section 41, and in the southern section 32. The cause of this apparent change in the preference of the meadow-larks of central Illinois seems, therefore, something peculiar to themselves, and is still to seek.

### Birds of the Pastures

The birds of a given situation may be discussed from two quite different standpoints, both interesting and pertinent, and both really necessary to a complete understanding of the facts. We may consider the members of an assemblage of species there with first reference to their relative importance to the situation itself—with reference, that is, to their comparative numbers, or to the nature and effect of their activities; or we may consider the situation with first reference to its relative importance in the economy and life of each species of bird which inhabits or visits it. If this situation is woodland, for example, a bird found only in forests might, if a comparatively rare species, have very little importance—might produce very little effect in the situation because of its infrequent occurrence there, while to the species itself the forest situation would be all-important, as the sole place of its habitation. Its own significance in forests might be easily overbalanced by a very abundant species which should visit woodlands only occasionally, but whose average numbers there might be twice or thrice as large to the unit of area and time as those of the less abundant species inhabiting forests exclusively. Time will not permit me to illustrate this division of my topic from both these points of view, and I will limit myself to a few words in conclusion on the *pasture birds* as a group and on some of the more prominent pasture species with reference to their importance in pastures.

Pasture lands were the preferred resort of our most abundant mid-summer birds. That is, more birds were seen in pastures than in any other of the larger crop areas

of the state—2,107 in that situation as against 1,814 in meadows, 1,667 in fields of small grain, and 1,169 in fields of corn. Indeed, 27.2 per cent. of all the mid-summer birds determined by my observers were seen in pastures, 23.4 per cent. in meadows, 21.5 per cent. in small grain, and 15.1 per cent. in corn. The area in pastures was larger than that in meadows, however, and on this account, if we consider the number of birds per square mile, we must change this order of precedence. With a general mid-summer average of 645 birds to the square mile for the whole state, we have 920 to the mile for meadows, 878 for pastures, 962 for small grain, and 300 for corn. Or, if we take the number per square mile for the entire state as 1, 1.43 will be the density ratio for meadows, 1.36 for pastures, .87 for grain fields, and .47 for corn fields.

SUMMER BIRDS IN CROPS, 1907

| | Numbers | Ratio | Per Square Mile | Densities |
|---|---|---|---|---|
| Pastures | 2,107 | 27.2 | 878 | 1.43 |
| Meadows | 1,814 | 23.4 | 920 | 1.36 |
| Grain | 1,667 | 21.5 | 562 | .87 |
| Corn | 1,169 | 15.1 | 300 | .47 |
| Other | 983 | 12.8 | | |

Looking to the composition in species of this mid-summer pasture population, we find that more than half the summer resident birds of Illinois pastures belong to five species—the English sparrow, the meadow-lark, the crow-blackbird, the horned lark and the field-sparrow, relatively abundant in the order named; and this statement is almost as true of the three sections of the state as it is of the state as a whole. Comprising nearly 53 per cent. of the pasture birds of the entire state, these five species made 49 per cent. of those of northern Illinois, 61 per cent. of those of central Illinois, and 47.5 per cent. of those of southern Illinois. Indeed, the first four of these species were the most abundant pasture birds of the whole state for the whole year, occurring there in the following numbers: English sparrow, 1,394; crow-blackbird, 696; meadow-lark, 686; horned lark, 603; and field-sparrow,

230. These are consequently our most typical pasture birds. In the pastures of the state at large the English sparrow was the most abundant species, making 20 per cent. of all the birds seen in pastures during the summer months, and the meadow-lark was nearly as common, making 17 per cent. of these birds. The meadow-lark was, indeed, the *most* abundant pasture bird in both southern and central Illinois, the sparrow surpassing it only in the northern division of the state. The horned lark, on the other hand, was second in northern Illinois, but tenth in both central and southern Illinois, and fourth for the state as a whole. The crow-blackbird was third on the list for the whole state, fourth for southern Illinois, third for central, and sixth for northern Illinois.

Ten species comprised more than two thirds of the pasture birds of the state, and these same ten species made 63 per cent. of the birds of northern Illinois pastures, 80 per cent. of those of central Illinois, and 64 per cent. of those of southern Illinois. Besides the five species already mentioned, these were the flicker, the robin, the mourning-dove, the red-headed woodpecker, and the red-winged blackbird.

One general impression made by this preliminary examination of the present bird population of the State of Illinois is that of a remarkable flexibility and tenacity of the associate and ecological relationships of birds in the face of revolutionary changes in their environment. Apart from the results of the introduction of the English sparrow, and the direct destruction of game birds and birds of prey, the main effect of human occupation seems to have been the withdrawal of most of the prairie birds from the area devoted to Indian corn, and their concentration in pastures, meadows, and fields of small grain—situations which most nearly resemble their original habitat.

# THE LIFE CYCLE OF PARAMECIUM WHEN SUBJECTED TO A VARIED ENVIRONMENT

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STUDIES on the life cycle of *Paramecium aurelia* (*caudatum*) have been made by several investigators, the most extensive work being that of Calkins.[1] As is well known, his results showed that when Paramecium was bred continually in a culture medium of hay infusion, it passed through more or less regular cyclical variations in general vitality as measured by the division-rate. The marked periodical depression periods occurred at about six-month intervals and unless the organisms were "stimulated" at this time the culture died out. Minor depressions occurred about every three months, but from these recovery was autonomous. Joukowsky[2] and Simpson,[3] however, apparently found that certain cultures of this organism died out after being but a short time under culture conditions.

A constant culture medium is an important condition for the study of the consecutive phases of vitality, and of the effect of stimuli on the organism, but it is of interest, however, in the light of the results obtained by this method to determine the character of the life cycle of Paramecium when subjected to a varied environment. It is possible, of course, that some element is lacking in

[1] Calkins, G. N. Studies on the Life History of Protozoa. I, The Life Cycle of *Paramecium caudatum*. *Archiv f. Entwk.*, XV, 1, 1902. IV, Death of the A Series. *Journal Exper. Zool.*, I, 3, 1904.

[2] Joukowsky, D. Beiträge zur Frage nach den Bedingungen der Vermehrung und des Eintrittes der Konjugation bei den Ciliaten. *Verh. Nat. Med. Ver. Heidelberg*, XXVI, 1898.

[3] Simpson, J. Y. Observations on Binary Fission in the Life History of Ciliata. *Proc. Royal Society Edinb.*, XXIII, 1901.

a constant culture medium of hay infusion which is essential to the continued life of the organism, and that depression effects which appear more or less regularly are due, in part, to a process of slow starvation—rather than to a loss of the power of assimilation. Recovery from these periods is effected by various stimuli (beef extract, etc.), because the lacking factor, or factors, is thereby supplied. Calkins himself points out the marked similarity of the morphological changes which he obtained in the earlier cycles of his Paramecium cultures with those found by Wallengren[4] to occur in Paramecia which had been intentionally starved. I have also called attention to this similarity in discussing the life cycle of various hypotrichous infusoria and have suggested that the effect of such stimuli as beef extract, etc., may be essentially that of concentrated nutrition.[5]

In connection with some experiments on the effect of various stimuli on the life cycle of infusoria,[6] I have had occasion to carry a culture of Paramecium for over a year, and the data derived from this work are believed to throw some light on the effect of a varied environment on the life history of this organism.

On May 1, 1907, a "wild" Paramecium was isolated from a laboratory aquarium and placed on a depression slide in five drops of hay infusion. When this animal had divided twice, the four resulting individuals were isolated on separate slides, and in this manner were started the four lines, I-a, I-b, I-c and I-d, which compose this culture.[7] The culture has been continued by the isolation of an individual from each of these lines almost daily throughout the life of the culture up to the present time (May 6, 1908) and a record has been kept of the

[4] Wallengren, H. Inanitionserscheinungen der Zelle. *Zeit. f. allg. Physiologie,* I, 1, 1901.

[5] Woodruff, L. L. An Experimental Study on the Life History of Hypotrichous Infusoria. *Journal Exper. Zool.,* II, 4, 1905.

[6] Woodruff, L. L. Effects of Alcohol on the Life Cycle of Infusoria. *Biol. Bull.,* XV, 2, 1908.

[7] Further details in regard to the technique are given in previous papers.

Complete history of *Paramecium aurelia* (*caudatum*). Culture I, from start on May 1, 1907, to the present time, May 6, 1908, at the 465th generation. The rate of division is averaged for ten-day periods. The ordinates represent the average daily rate of division of the four lines of the culture. Above, the numbers of the ten-day periods are indicated. Below are designated the periods in which the fifteenth day of the respective months fell. The figures, 100, 200, etc., represent generations and are placed in the periods in which they were attained.

daily bipartitions of each line. The following curve represents graphically the average rate of division of the four lines of the culture, and this again averaged for ten-day periods.

The culture was carried on at the Thompson Biological Laboratory of Williams College, Williamstown, Mass., during May and June, 1907; at the Marine Biological Laboratory, Woods Holl, Mass., during July and August, 1907; and at the Sheffield Biological Laboratory of Yale University, New Haven, Conn., from September, 1907, to the present time, May, 1908.

The culture medium during the earlier months of the work consisted of hay or grass infusion. But, except during periods in which the culture was employed as a control for certain experiments, the infusion was made with hay or grass from various localities and different proportions of hay and water were used almost daily. Water from various sources was employed. In every case the temperature of the infusion was raised to the boiling point, and then allowed to attain the temperature of the laboratory before being used. In some cases the infusion was made fresh daily, in other cases it was allowed to stand twenty-four hours before being used.

Beginning in February, 1908, a much more varied culture medium was employed. It was found that Paramecium can exist in nearly any infusion which may be made from materials collected in ponds and swamps, and accordingly, in the hope of supplying as far as possible all the elements which may be encountered in the "normal" habitat of the organism, water was taken from ponds, laboratory aquaria, etc., together with its animal and plant life. In other words, no definite method was employed in selecting the material, but it was simply collected at random from many sources, thoroughly boiled, and then used. This culture medium affords a striking contrast to that employed by Calkins, which he described thus, "The hay infusion was made every day, the same amount of hay and water being taken each time and

raised to the boiling point. This method was never varied during the entire period of the cultures and the salt content of the water, as shown by weekly analyses, did not vary beyond a very slight fraction of one part to one hundred thousand."

The only condition present in the life of this culture which could not be encountered by a wild Paramecium was the boiled condition of the culture medium, but this was essential in the experiments in order to prevent the introduction of an encysted or active wild individual into the culture.

The objection might be made that the environment was changed too frequently and too greatly to afford natural conditions. But, if the hundreds of millions of wild individuals which are derived from a single wild Paramecium are considered, and if the environment of any four lines of descent of four individuals existing at the end of twelve months in the wild state is taken into account, it will be readily appreciated that the surviving organisms have probably experienced far more changes of medium than have the four lines of the culture under consideration. It may be that only those individuals which have encountered varied conditions have survived without resorting to conjugation.

It is obvious, indeed, that all the variations in environment which may be experienced by a wild Paramecium have not been supplied; for in a pond considerable changes of temperature occur during the year, and periods of rest by encystment or lack of food are afforded. It is believed, however, that the conditions under which this culture has been carried approach nearer to those encountered by the majority of wild individuals than has been the case in previous investigations.

A glance at the plotted curve of the life history shows that at no ten-day period during the life of the culture up to the present time has the average rate of division of the culture fallen as low as one division in two days, the nearest approach to this rate being attained at period

twenty-two in December, 1907, when the culture was subjected to a particularly uniform culture medium. The highest rate of division so far attained occurred at period ten in July, 1907. The average rate of division for the entire year is obviously considerably above one division per day, the organisms being in the 465th generation on May 6, 1908. That this is not the maximum rate of division of which the culture is capable is shown by the fact that a culture isolated line by line from the one under consideration and treated daily for six months with alcohol is at the same date in the 505th generation.

The major fluctuations in the division rate which have occurred in the life of this culture are all "rhythms" (using this term in the sense in which I employed it in discussing the life history of Oxytricha) and so far no "cycle" has been completed. Calkins in his earlier papers on Paramecium believed the cycle to be of three months' duration, agreeing in this regard with certain of the earlier investigators on this form. In his last paper on the subject, however, as has been noted, he interpreted the tri-monthly fluctuations as simply minor changes from which recovery was autonomous and regarded the cycle as the larger semi-annual fluctuations, recovery from which was only brought about by stimuli. I have previously interpreted these trimonthly depressions as rhythms and the results obtained from this culture would seem to show that the semi-annual cycles of Calkins are also merely rhythms—recovery from which was not autonomous under the conditions of a constant environment. This culture shows that the cycle of Paramecium under a varied environment may be considerably over a year in duration, since the culture at present shows no sign of waning vitality.

This suggests the much-discussed question as to whether the protozoa are potentially immortal, and the rôle of conjugation in the life history. Up to the present time there has been no tendency among the individuals of this culture to conjugate, although in the "stock" cultures,

comprising individuals left over after the daily isolations, there has been every opportunity for its occurrence. Of course there has been no possibility of conjugation in the four direct lines of the culture on account of the daily isolations. This result agrees with that which I obtained with my cultures of various hypotrichous forms—and I believe it suggests strongly that conjugation must be regarded as a more or less variable phenomenon which occurs in the life history when conditions are adverse for the normal life of the organism, and which is not necessary under the conditions of a varied environment. I believe it is customary to regard conjugation as of far more frequent occurrence than it actually is in the life history of "wild" individuals, because it is brought to the attention in laboratory cultures and "hay infusions" which pass through a series of changes—changes which inevitably bring about conditions unfavorable to the continued reproduction of the organisms, and which are compensated for by conjugation.

No period of marked physiological depression is indicated by the division-rate of this culture during the first year of its life; but well-defined morphological changes have occurred. These cytological variations, chiefly nuclear, demand further study. It is evident, however, that the relation of the rate of division to the so-called "normal" condition of the nuclear apparatus of Paramecium is not substantiated by this culture, as profound nuclear changes apparently do not affect the rate of division. I believe from a study of this culture and "wild" cultures in large laboratory aquaria, that various nuclear changes which are not at present recognized occur normally in the life history of Paramecium, and that possibly when conjugation between two individuals is prevented, either under the conditions of culture or in the "wild" state, a rearrangement of the nuclear apparatus is resorted to which may be analogous to endogamy, or conjugation of nuclei within the original cell.

# PLACOBDELLA PEDICULATA n. sp.[1]

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IN the summer of 1889, while at Lake Pepin superintending the zoological work of the Geological and Natural History Survey of Minnesota, Professor Nachtrieb found that some of the sheepsheads (*Aplodinotus grunniens*) which were being seined from the lake in large numbers by the local fishermen had a large parasitic leech fastened to the isthmus or shoulder under the gill cover. Three of these leeches were collected at that time, with portions of the fish showing the place and manner of attachment. One of these specimens was later sent to Professor J. Percy Moore, who found it to be a new species of *Placobdella* and suggested the specific name *pediculata*. All the specimens originally collected were adults, gorged with blood, and greatly modified in form from the usual *Placobdella* types by their close parasitic habit; so that, in some parts, annulation and many other external features had been entirely obliterated. It was seen at once that to determine these features younger and better-preserved specimens must be obtained. Accordingly, during the first part of September, 1903, I spent several days with the fishermen around the head of Lake Pepin examining fish for this leech. During this time I examined many hundreds of fish and succeeded in obtaining three small specimens, none of which were over a centimeter in length.

## HABITS

*Placobdella pediculata* appears to be a true fish parasite, having been found only in the gill chamber of the

[1] From the laboratory of the Department of Animal Biology, the University of Minnesota.

fresh-water sheepshead, the posterior sucker of the leech being deeply imbedded in the side of the isthmus or shoulder. In the case of young leeches which have not been long attached, the depression caused by the posterior sucker is comparatively shallow, being a mere external depression in the inflamed tissues of the fish. As the attachment continues the inflamed tissues of the host grow up like a collar and close in around the leeches body in front of the sucker. This closing in of the inflamed collar presses upon the body of the leech, narrows it to a slender peduncle in front of the sucker and in-

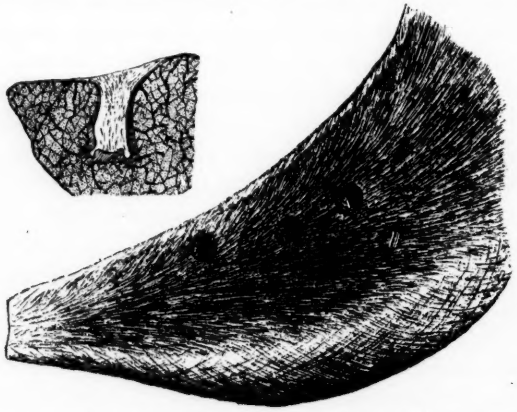

FIG. 1. The shoulder of a sheepshead with three depressions from which the leeches have been removed and one of the depressions cut in two lengthwise.

cidentally crowds the sucker down into the tissues of the fish, so that, in time, this depression may reach into the underlying muscles to a depth of half an inch or more and have an opening of about a quarter (or less) of an inch in diameter. The bottom of the depression has a larger diameter. Fig. 1 represents the positions of three depressions from which the leeches have been removed, and one of the depressions cut in two lengthwise.

These leeches are capable of becoming greatly contracted, and when one is disturbed it draws back until it appears as a mere brownish pyriform knob which entirely covers the place of attachment.

The burying of the posterior segments in the tissues of the host has brought about an interesting structural change so that we find the anal opening shifted forward to a position between somites XXIII and XXIV instead of between somites XXVII and XXVIII, as in the other members of the genus. It is noticeable that, while the young leeches whose posterior portions are not yet deeply imbedded have the characteristic position of the anus (XXIII–XXIV), the outline of the posterior part of the body is still a regular curve showing none of the pedicular characteristics so pronounced in the older individuals. The posterior sucker, however, is very strongly developed even in those not more than a centimeter long.

Practically nothing is known of this leech separate from its host, but it seems possible that a part of its existence may be spent elsewhere. During September, 1903, I examined several thousand fish of this species from Lake Pepin and found only three isolated leeches, each about a centimeter in length. The posterior sucker, while imbedded in the tissue, was not sunk in deeply and so had not produced the characteristic peduncle. They were evidently young ones which had recently attached themselves to their hosts and were gradually sinking the posterior sucker into the host's flesh. As full grown specimens, deeply imbedded, were found in the same locality during August of 1899, at least some of the adults must remain with their hosts during the summer and probably throughout the year.

## Description[2]

Like *Placobdella parasitica* and *P. rugosa*, this is a species of large size, though not quite equaling the largest

[2] This description is based upon both young and large mature specimens gorged with blood. In view of unavoidable delay in the publication of Professor Nachtrieb's projected report on the leeches of Minnesota, Professor Moore kindly consented to the free use of his description prepared for the systematic portion of the report here alluded to. I have retained the specific name suggested by Moore, though his description, being based upon a single large, gorged and much contracted specimen, was of necessity somewhat incomplete.

examples of the forms mentioned. It is more than usually contractile and therefore difficult to preserve in a suitable condition for study. The outline is very characteristically pyriform and strongly convex dorsally, as shown in the figures. But the most striking peculiarity is the attenuation of the posterior somites to form a narrow pedicel just in front of the posterior sucker, which consequently stands out freely in a most characteristic manner. The oral sucker has the same structure as in *P. parasitica.*

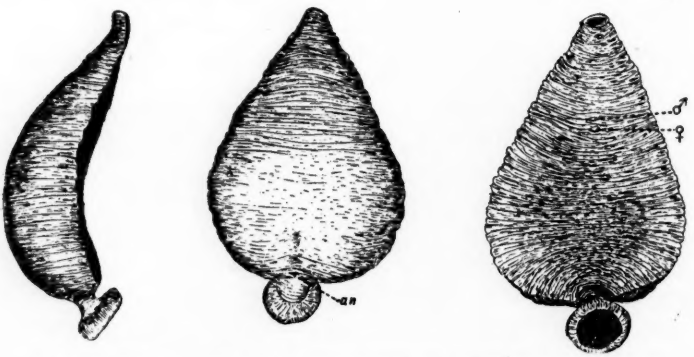


FIG. 2. Lateral, dorsal and ventral views of a mature specimen gorged with blood.

No trace of cutaneous papillæ can be detected, the skin being perfectly smooth. The segmental sensillæ and scattered sense organs are very indistinct. Eyes are very difficult to detect in the mature animals, but appear as small pigment masses at III–IV in the young. The annulation is essentially like that of *P. parasitica* excepting the caudal peduncle and the generally simpler structure of the corresponding somites of *P. parasitica.*

Somites I and II contain each but one annulus. Somites III and IV are biannulate and V is biannulate dorsally, but ventrally the furrow fades away medially. VI is triannulate above, but the furrow a1–a2 is incomplete below. Somites VII to XXIV are triannulate, but

the furrow a1–a2 is incomplete medially on the ventral side of both VII and VIII, and in most of the succeeding sonites is less marked than either a2–a3 or the intersegmental furrows. In the anterior somites and to a less degree in the posterior, a3 is slightly longer than a1 or a2. The annulation of the post-anal somites, constituting the caudal peduncle, is irregular and somewhat puzzling on the older specimens, but is fairly distinct on the younger ones. Somite XXIV, which immediately succeeds the anus, is triannulate. Somites XXV, XXVI and XXVII are all biannulate, but a1 of somite XXV is partially divided and a1 of both XXVI and XXVII is

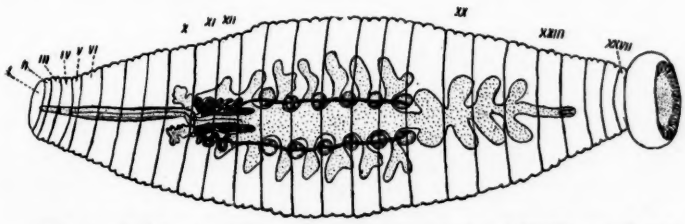


FIG. 3. Sketch of a young specimen showing somites I–XXVII, annuli and relative positions of the eye (*e*), proboscis (*prob*), esophageal gland (*oeg*), enlarged portion of the vas deferens communis (*s*), ovary (*ov*), testes (*T*), vas deferens communis (*vdc*), intestine (*int*) and anus (*an*).

larger than a2. Neither annulus of XXVII is complete, a1 reaching only to the sides of the body and a2 not as far. The disc is composed of somites XXVIII to XXXIV. The accompanying Fig. 3 represents the arrangement of the furrows in a young animal. Somite XXIV is the last segment of the body proper and its posterior boundary forms in contracted specimens a fold which envelops the contiguous portion of the narrowed peduncle. The latter continues to narrow to the sucker, to the middle portion of which it is strongly attached for rather more than the posterior half. The posterior sucker is larger, circular and directed strongly ventrad. The nephridiopores are in the sensory annuli of somites VIII to XI and XIII to XXIII and are placed similarly to those of *P. parasitica.*

The mouth is very small and situated far forward near the anterior rim of the sucker in somite II. As in related species, the proboscis is slender and the crop is provided with seven pairs of large cæca reaching nearly to the margins of the body. The cæca, however, are less deeply and finely divided than in *P. parasitica,* each of the first six pairs exhibiting only two or three rather short lobes. The intestine reaches to the posterior part of somite XXIV or even beyond and then bends abruptly forward toward the dorsum as an extremely narrow rectum reaching to the minute anus situated at XXIII–XXIV. The forward curvature of the rectum and the anterior position of the anus are unique features in the family. The salivary glands are widely scattered through the anterior two thirds of the body. On either side of the esophagus in somites X and XI lie a pair of compact esophageal glands which join the esophagus by a short duct in somite XI.

The reproductive organs are essentially similar to those of *P. parasitica.* The male and female external orifices are situated at XI–XII and XIIa2–a3, respectively. Six pairs of testes are crowded between the bases of the gastric cæca. The large sperm sack and the ejaculatory duct of the vas deferens form a compact snarl in somite XII in the immediate neighborhood of the atrium. Nothing is known of the early stages of development.

# MARINE LABORATORIES, AND OUR ATLANTIC COAST

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WE are fortunate above all civilized nations in having in the range of our Atlantic sea-board a unique diversity of conditions affecting marine life. The arctic current creeps down the northern New England coast to Cape Cod, and during the winter the strong northeasterly winds drive its cold waters southward to the mouth of the Chesapeake. In summer, however, the southerly winds reverse these conditions, and the warm surface waters from the Gulf stream are drifted upon the shores between Cape Hatteras and the southern side of Cape Cod.

Another well-marked region is that between Cape Hatteras and Cape Canaveral, Florida, where we find a very characteristic warm-water fauna, which is again distinct from that of the coral reef region of Florida, south of Miami.

Thus, broadly speaking, there are four well-marked faunistic regions along our coast, and each affords its own peculiar problems for research. A mainly arctic fauna is found from northern Maine to Cape Cod, a transitional and seasonally fluctuating fauna from the southern coast of New England to Cape Hatteras, creatures of a warm sea from Cape Hatteras to Cape Canaveral, Florida, and a strictly tropical colony from Biscayne Bay, Florida, southward.

The physical features of the coast itself are also most important in determining the character of the animals of the shore. Thus the rocky wave-worn ledges of the coast of Maine, the varied character of that of southern New England, the monotonous stretch of shifting sand be-

tween Sandy Hook and Cape Canaveral, and the coral reefs of Florida, have each their own peculiar fauna and impose their own limitations upon the diversity of animal life. A diversity which is accentuated by the fact that in Florida we find a tidal rise and fall of less than two whereas in northern Maine the diurnal range is more than thirty feet.

Moreover, the relatively brackish and protected waters, such as those of Long Island, Pamlico and Albemarle Sounds, Chesapeake and Delaware Bays, and the tortuous estuaries and salt-water creeks of the Carolinas and northern Florida, have faunæ differing widely from those of the more richly endowed outer sea-beaches.

It is therefore evident that in so far as research is concerned no one biological laboratory can grant facilities other than those limited by the conditions of its own locality. The purposes of research demand that we establish a series of stations at salient points from Maine to southern Florida.

On the other hand, the successful prosecution of research demands that our youth be trained to its performance, and to this end it is essential that certain of the more centrally situated laboratories should devote some part of their energies to the giving of primary instruction.

Such instruction should, I believe, be given only in those laboratories which are placed near large centers affording the advantages of accessibility and diversity of intellectual interests. On the other hand, a certain remoteness from the busy world and consequent freedom from interruption is peculiarly favorable to the conduct of research, and it is interesting to observe that the only laboratory, along our coast, devoted exclusively to research is placed upon the most inaccessible island along the entire range from Maine to Florida.

At present we find one laboratory at South Harpswell, Casco Bay, Maine, a great center at Woods Holl, another at Cold Spring Harbor, in Long Island Sound, another

at Beaufort, North Carolina, and one at the extreme westerly and southerly end of the Florida Keys.

No laboratory has as yet been established along the interesting coast between Hatteras and Sandy Hook, with its peculiar transitional fauna; yet such situations as Cape May, or Linhaven, or Willoughby Harbors in Hampton Roads, would afford a suitable site for such a station.

It is not so remarkable that no laboratories have been established upon the inner shores of Delaware or Chesapeake Bays, or at Pamlico or Albemarle Sounds, for in these brackish inland waters the fauna is but limited in comparison with the rich variety of forms to be found along the exposed sea-beaches. In future, indeed, we should endeavor to avoid the error which has, in places, been made of building our laboratories in situations from which the open water is not readily accessible at all times, for it is peculiarly true of every laboratory that the animals which afford the subjects of its most significant researches are invariably those which may be obtained in abundance in the near neighborhood of the station itself. It is, therefore, most desirable that the laboratory be placed in close proximity to the richest collecting grounds of the region.

It is remarkable that so little effort has been made to properly install a laboratory for general instruction and research upon the coast of New England north of Cape Cod Bay. Yet here we find one of the most sharply differentiated of the faunistic divisions of our coast. The welfare of research in marine biology demands the adequate maintenance of such a station.

Returning recently from a visit of half a year to various biological centers in Europe the writer has formed the impression that the scientific results which have been achieved by investigators in our marine laboratories have won the admiration of European students, while at home our intelligent public is only beginning to awaken to the fact that they are worthy of respect.

In America, however, we may consider it fortunate that in order to win that form of recognition which leads to advancement in material as well as in intellectual well-being, it is necessary that our institutions of learning should attract the respectful interest of broad minded men of culture who are also leaders in the great affairs of the commercial world. Much may be learned by those desirous of furthering the already superior work of our laboratories, through a study of the methods of management of the great museums of New York City. Certain it is that the direction of any successful laboratory demands a two-fold capacity. On the one hand, we face a problem of expenditure and receipts, and on the other hand, a dependent but widely different problem of the scientific scope and aim of the institution. A neglect to attain to excellence of management from the purely commercial standpoint, must react unfavorably upon the ability of the institution to attain toward the realization of its proper ideals in scientific achievement. It appears to the writer that our institutions of learning which are dependent upon the public for support owe it as a duty to publish annually a clear, detailed and perfectly intelligible financial statement. Surely funds devoted to the giving of instruction or the prosecution of research can not be too carefully accounted for or too wisely expended.

It is unfortunate that throughout the length of our great Atlantic seaboard there is no situation well suited to the establishment of a marine laboratory which may remain active throughout the year. In winter the frozen harbors of the north, the relative inaccessibility and desolation of the Carolina shores, the hurricane season of Florida interpose practical barriers to the plan of maintaining any one of our stations constantly open. We have no Naples with its brilliant bay, its genial climate, and over it as a veil the association of history deepening every charmed impression of its beauty.

# BIOMETRY AS A METHOD IN TAXONOMY[1]

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We take it for granted that the systematic description of plants, and animals, is not the province of the amateur, however interested he may be in a special group of living things. To the contrary this work should be done by the professional botanist, or zoologist, and demands a high grade of trained skill and judgment. More intelligence is needed than suffices to carefully fill out a card for a catalog, and yet how often do we find descriptions of species that would be discreditable to even a librarian's assistant!

The characters of one species are sometimes described as "smaller," "longer," "darker" or "lighter" than those of another, but upon reading the description of the other species referred to, the characters are again equally lacking in exactness. It is useless to enlarge upon this item, for every naturalist is sadly familiar with such imperfect and inadequate descriptions.

Biometry offers a method of great value for the study of specific characters, and the consequent clear and definite statement of the results of such study. There are workers either frightened at the mathematics of the method, or scornful of the whole thing on the general principles of conservatism, or prejudice. The mathematics of biometry, considered merely as a biological working method, is that of simple arithmetic, with no operation more complicated than the extraction of the square root.

It is certainly of great advantage to record in the standard deviation an exact mathematical statement of the variability of a character in place of the sometimes ut-

[1] Read at the Seventh International Zoological Congress, Boston, August, 1907.

terly meaningless, or again only partly useful, qualitative phrases which may be given. The correlated variability of some of the characters is important. Descriptions based on the mean and range of variation of each character and so expressed are better than those based on values taken here and there at random and then, when once published, petrified into a specific type ideal. A naturalist later tries to identify a specimen with this very limited description, but the characters of the specimen are too divergent and so a new species is created. Still later another naturalist works with a hundred specimens, including the characters given for the two preceding species, and then synonymy is born and with it trouble forevermore.

As an illustration of the usefulness of biometry for the solution of taxonomic problems I may take the case of the common Florida-Caribbean holothurian described in 1851 by Pourtalès as *Holothuria floridana*. In 1868, Semper considered this species identical with *H. atra* Jäger, 1833, from the Celebes. All authors have followed Semper to the date of my publication (1905). In the meantime Ludwig, in 1883, recognized a species in the West Indies different from the Indo-Pacific form and failing to identify it with *H. floridana* Pourtalès, created a new species, *H. mexicana*. The same error was repeated by Theél, in 1886, in making his *H. africana*.

With a feeling that things were not as currently accepted, I concluded to apply the method of biometry to this problem. From the United States National Museum, Harvard University, and my own collections, 138 specimens, covering nearly the whole geographical distribution of the two species were available for the work. In the solution of the general problem before me no attempt was made to determine place modes of which, in minor details, there were sometimes indications. Every important character was submitted to statistical study and the result is that *H. floridana* Pourtalès is reestablished as a valid species, with *H. mexicana* Ludwig and *H.*

*africana* Theél as synonyms. The old characters have been redefined, new ones added, and those differentiating *H. atra* and *H. floridana* clearly stated. The young and old have been segregated and differentiated and the results of growth determined. The nature and extent of the variation of each character has been recorded. An entirely new character for holothurians has been discovered in what I have called "pits," in the body-wall of *H. atra.*

It is not possible in taxonomic work to give several years to the study of each species and it often happens that the material is not sufficient. If an author will make a thorough biometric analysis of the characters of at least one species in his group, he will gain a rare insight into the relative values of the characters. The method is searching and leads to especial carefulness in investigation and statement. Even if one has not an ideal number of specimens his determinations are checked by their probable errors. In the case of some characters, as for instance, the spicules of holothurians, an abundance of material is present in each specimen. More and more of the anatomy becomes involved as the work progresses. Now that the individuality and continuity of the chromosomes has been demonstrated, McClung has suggested that their number and grouping constitute family, generic, and specific characters of just as definite worth as those that heretofore have been employed. The more characters studied the better, and the ideal taxonomy will be based upon the whole life-history. Then the error of describing the young and old of a species as independent species will not be repeated.

It naturally follows from biometric analysis that a group of individuals, giving as much as possible of the range in variation, should be established and deposited, preferably in a national museum, as the specific type group rather than some arbitrarily selected type specimen. We have instances of specific descriptions based upon one individual, with an apology by the author for

the lack of anatomical details because he could not dissect the one precious specimen!

The best way to avoid trouble in taxonomy is to begin with making the original description as complete as possible. It is then a simple matter to condense for practical diagnostic purposes. The biometric determination of the variability of the different characters allows of their arrangement in the order of increasing variability and will perhaps demonstrate which are the "best" characters. It is too soon to state exactly what percentage of divergence justifies the creation of a variety, or of a species, and it is not probable that any universally applicable measure will be established.

Biometry gives us data of value bearing upon one or more of the factors of evolution and records them in the best form for use. We know that under varying environmental conditions different varietal, or specific forms respond. The new forms may be only temporary and followed by still other new forms, under other changed conditions, or with reversion, when the old conditions are restored. Characters, whether expressed in the terms of biometry, or not, are not permanently fixed by the publication of a specific description. It is to be hoped that the spirit of Darwin is with us yet and that we realize that species are in a state of evolution, either continuously or discontinuously, slowly or rapidly. If we are to follow species in their evolution we must have exact and comprehensive statements of their characters from time to time as it is possible, and, if in the terms of biometry, these statements are always in harmony and comparable.

If then, while performing the necessary work of taxonomy, we can make our descriptions more complete and nearer the truth; if occasionally we may be relieved of the necessity of creating a new species; if our work may contribute to the advancement of the philosophy of biology, should we not welcome biometry as a method which can well serve in one and all of these things?

# SHORTER ARTICLES AND CORRESPONDENCE

## THE GENUS PTILOCRINUS[1]

Mr. F. A. Bather has just made known a second species of the interesting genus which I described a year ago[2] under the name of Ptilocrinus; his material was obtained in 70° 23′ S. lat., 82° 47′ W. long., at a depth of about 480 meters; the color of the animal in life is recorded as "flavus brilliant."

The type species of Ptilocrinus, *P. pinnatus*, came from the Queen Charlotte Islands, off British Columbia, and was dredged at a depth of 1,588 fathoms, about six times the depth at which *P. antarcticus* was found.

Although at first sight, perhaps, it is somewhat surprising that the two known species should be found so far apart geographically and bathymetrically, if we look closely into the matter we find that it is quite what we should expect. Geographically and bathymetrically the recent crinoids are divisible into three well-marked faunæ: (1) the Indo-Pacific-Japanese, characterized by the families Zygometridæ and Himerometridæ, the genera Comatula, Phanogenia, and most of the species of Comaster in the Comasteridæ, the genera Ptilometra, Asterometra, Calometra and one of the two species of Tropiometra of the Tropiometridæ,[3] and the genera Perometra, Nanometra, Compsometra, Thysanometra and Iridometra of the Antedonidæ; among the stalked crinoids Metacrinus, Carpenterocrinus, Hypalocrinus and Phrynocrinus are only known from this region; (2) the Polar-Pacific, including the Arctic and Antarctic circumpolar areas, and the entire American coast of the Pacific from Bering Straits to the Straits of Magellan, the coasts of eastern Asia to southern Japan (where it meets the preceding at Tokyo Bay), including the Sea of Okhotsk and the Sea of Japan, and the Atlantic coasts south to near the Hebrides and the Faroë channel, and to the

[1] *Ptilocrinus antarcticus* n. sp., a crinoid dredged by the Belgian Antarctic Expedition. *Bull. de l'Acad. roy. de Belgique* (classe des sciences), No. 3, mars, 1908, pp. 296–299, fig. p. 299.

[2] *Proc. U. S. Nat. Mus.*, XXXII, p. 551, fig. 1, p. 552.

[3] The second species, *T. carinata*, appears to have recently extended its range into the Atlantic.

Gulf of Maine, characterized by various genera belonging exclusively to the Antedonidæ, Heliometra occurring everywhere, Hathrometra confined to the north, and Isometra to the south, while Thaumatometra occurs in the south, but extends northward in the Pacific to the Aleutian Islands; among the stalked crinoids the *Bathycrinus carpenterii* type (*B. carpenterii, B. complanatus* and *B. australis*) appear possibly to be peculiar to the region; bathymetrically, the characteristic forms (except Bathycrinus) are inhabitants of comparatively shallow water in both polar areas, but dip downward to a considerable depth when passing under the tropics; and (3) the Oceanic, which occurs everywhere in moderate to very deep water with the Indo-Pacific-Japanese, and extends thence over the entire ocean area, *except* that it does not intrude into the area occupied by the Polar-Pacific; the characteristic forms are the species of Thalassometra having rounded and spiny rays and arm-bases (such as *T. bispinosa, T. villosa, T. gigantea, T. pubescens, T. multispina* and *T. aster*) and certain other species, such as *T. flava, T. porrecta* and *T. magnicirra,* Stylometra, Bathymetra and Charitometra, except the *aculeata, hepburniana, basicurva* and *tuberosa* groups; of stalked crinoids, Rhizocrinus, Endoxocrinus, and the species of Bathycrinus, except the *B. carpenterii* group, belong here; the West Indian fauna falls almost wholly in the last division, but there is a trace of Indo-Pacific-Japanese influence, as, however, we might expect, since the entire Oceanic fauna is a direct, though considerably modified, derivation from it, even the well-known subgenera of Pentacrinitidæ, Encrinus[4] and Isocrinus being only a comparatively slight advance over the apparently more primitive Metacrinus type. The Mediterranean—northeast Atlantic fauna, characterized by Antedon (*A. mediterranea, A. bifida* and *A. petasus*) and Leptometra, appears to be a localized offshoot from the Polar-Pacific.

Bearing these facts of distribution in mind, we are not surprised to find Ptilocrinus where Mr. Bather found it, for it appears to be a genus of the Polar-Pacific area, and the same *may* be true of Calamocrinus. Although Heliometra occurs throughout this area, the two arctic species, *glacialis* (= *eschrichtii*) and *quadrata* (with their representatives in the Sea of Okhotsk, *maxima* and *brachymera*) differ from the Antarctic and east Pacific species in the smoothness of their arms, and in

[4] The subgenus Cenocrinus of Wyville Thomson.

a different distribution of the brachial syzygia; we find, therefore, that the entire Pacific portion of the Polar-Pacific area, from Bering Straits to the Antarctic Ocean, is really an extension of the latter division of the Polar-Pacific area northward; so that, had we reasoned backwards from the facts at hand before the appearance of Mr. Bather's paper, we might very well have prophesied the discovery of a Ptilocrinus in the Antarctic regions.

Mr. Bather remarks that I did not publish a generic diagnosis when I established Ptilocrinus; I did not, for the reason that in a monotypic genus, we are quite unable to say which are generic and which specific characters, and to tell in what way a new species will differ from the type; it is all right to indicate the differences provisionally between a new monotypic genus and older genera, but drawing up a diagnosis of a new monotypic genus implies rather more of a proprietorship over the animal kingdom than I am willing to assume.

AUSTIN HOBART CLARK.

UNITED STATES BUREAU OF FISHERIES.

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## A NEW RHINOCEROS FROM THE LOWER MIOCENE OF NEBRASKA[1]

Among several animals found by the writer at Agate, Sioux Co., Nebraska, in the spring of 1905, was a new form of hornless rhinoceros.

The type (No. HC105, collection of the writer) consists of a complete skull, the posterior portion of the left jaw, the atlas and the axis. This description has been delayed, hoping additional material might be secured.

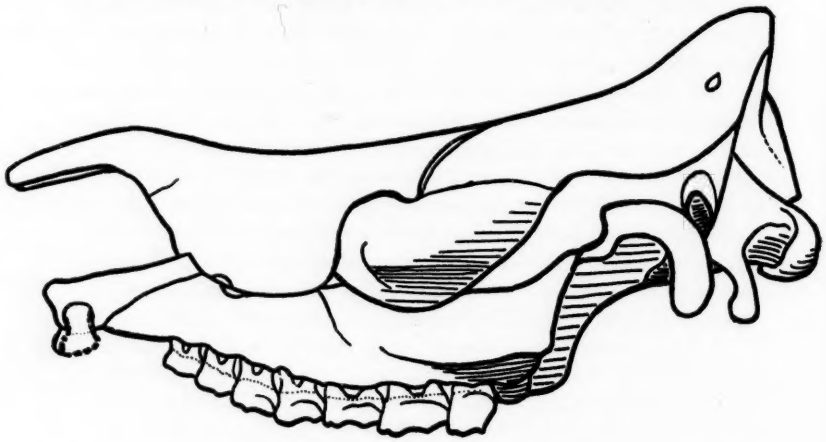
The specimen was found in an exposure of the Dæmonelix Beds, about four miles west of the well-known Agate Spring Fossil Quarry, on the ranch of James H. Cook. The bone horizon in this quarry is practically, if not identically, the same as that in the Agate Spring Quarry. Strictly speaking, the Dæmonelix Beds are an integral part of the Lower Harrison Beds, forming the upper portion of them.

Associated with this specimen were the remains of Syndyo-

[1] Extract from a paper read before the American Society of Vertebrate Paleontologists, December 29, 1907, at New Haven, Conn.

ceras, Miolabis, Merychyus, Thinohyus, Parahippus, Moropus, Brachypsalis and other animals.

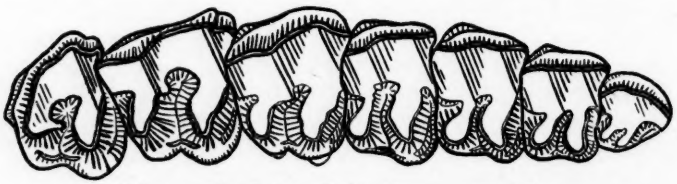
The specimen is referred to the genus Aceratherium, and the specific name of *egregius* is proposed. It is separated from its contemporary Diceratherium, by the absence of horn cores, or



*Aceratherium egregius* Cook. ¼ natural size.

any trace thereof on the nasals; by a relatively longer and proportionately narrower skull; by a larger first upper premolar, and by many minor features.

The nasals are broad and flattened posteriorly, narrowing rapidly anteriorly, and extending about one half inch in front



Molar-premolar Series. Right side. ½ natural size.

of the premaxillaries. The temporal ridges unite in forming a sagittal crest, which rises quite abruptly, adding materially to the general saddle-shaped appearance of the skull.

A more complete report will appear in volume three of the Nebraska State Geological Survey.

MEASUREMENTS

| | Mm. |
|---|---|
| Greatest length | 473 |
| Extreme width across zygomatic arches | 245 |
| Distance between orbits across frontals | 140 |
| Width of brain case | 90 |
| Length of upper molar—premolar series—left side | 202 |
| Length of upper molars, left side | 95 |
| Length of lower molars, left side | 100 |
| Length of diastema P. 1 to incisor | 61 |

HAROLD JAMES COOK.

THE UNIVERSITY OF NEBRASKA,
March 1, 1908.

# NOTES AND LITERATURE

## PLANT CYTOLOGY

**Some Recent Research on the Cilia-forming Organ of Plant Cells.**—The blepharoplast, or cilia-forming organ of plants, is present in the sperms and other motile gametes and in the zoospores. When fully developed it lies close against the plasma membrane of the cell in the form of a granule or band of various shapes to which the cilia are attached. The origin of the blepharoplast has been the subject of considerable research with conflicting conclusions.

Strasburger in 1900 from studies on the zoospores of Œdogonium, Cladophora and Vaucheria decided that the blepharoplast arose in the plasma membrane (Hautschicht), the nucleus lying in close proximity at the time of its formation; Mottier later described a similar origin for the blepharoplast of Chara. In sharp contrast to the above conclusions are those of Belajeff from studies on the sperms of certain pteridophytes, Ikeno for Cycas and Marchantia, and Hirasé for Ginkgo, who hold that the blepharoplast is an attractive sphere or centrosome. Belajeff in particular has consistently described the blepharoplast as occupying, as a centrosome, the poles of the spindle in the mitosis previous to the formation of the sperm mother cells, and has held that the blepharoplasts of Marsilia came from centrosomes passed on from the previous mitoses; each sperm mother cell being thus supplied with a blepharoplast. Ikeno, especially from studies on Marchantia, also holds to the centrosome nature of the blepharoplast, but his conclusions are disputed by Miyake. A third group of investigators to which Davis and Yamanouchi also belong (as will be noted from the reviews which follow) have described the blepharoplast as arising in the cytoplasm while the nucleus is in a resting condition, and as holding no genetic relation to any preceding mitoses. Thus Webber from very thorough studies on the cycad Zamia described the blepharoplasts as developing *de novo* on opposite sides of the nucleus and at some distance from it before the mitosis that precedes the differentiation of the sperm nuclei; Shaw for Marsilia also

claimed that the blepharoplasts did not occupy the poles of the spindle in the final mitosis, as would be expected of a centrosome-like body.

These divergent views have great theoretical interest in relation to the subject of the polar organization of cells reviewed in the July number of the NATURALIST. Zoospores invariably present a conspicuous polarity since their cilia are situated at one end or at a definite point on the side, and while the complex coiled structure of many sperms obscures this polar organization the process of blepharoplast development is always from a region which is clearly a pole of the cell. Indeed, these types of cells present some of the best illustrations of complex polar organization. Perhaps the most vital problem of zoospore formation and spermatogenesis is then the question whether or not the polar organization of these cells arises *de novo* at the time of their development or is handed on from the succession of cells which are their progenitors.

Davis[1] found in the zoospores of Derbesia a very interesting subject for the study of a remarkable blepharoplast. Derbesia is a marine green alga in the group of the Siphonales, distinguished from other forms in the same group by having very large zoospores, each of which is provided with a circle of numerous cilia. These zoospores are developed in a large sporangium which contains at first several thousand nuclei, but a process of nuclear differentiation begins very shortly in the young sporangium; certain of the nuclei increase in size while the great majority begin to degenerate and finally break down. The large surviving nuclei become distributed rather uniformly throughout the protoplasm of the sporangium, and each is evidently the center of dynamic activity for the cytoplasm in its vicinity. This is indicated by the arrangement of numerous conspicuous protoplasmic strands which radiate from the nucleus between the surrounding plastids.

The segmentation of the protoplasm does not begin until the process of nuclear degeneration is practically ended, and the sporangium contains only the larger nuclei (from 30–300), which are to take part in spore formation. Cleavage furrows start from the periphery of the sporangium and cut into the protoplasm in the form of curved and branching furrows.

[1] Davis, B. M. Spore Formation in Derbesia. *Ann. of Bot.*, XXII, p. 1, 1908.

These at first mark out large areas, which, however, become successively smaller as new furrows are formed at the periphery or strike off from the sides of the older ones. Finally the protoplasm of the sporangium becomes divided into approximately equal masses around the large surviving nuclei. These masses are the zoospore origins and each develops into a uninucleate zoospore.

The nucleus first lies at the center of the zoospore origin, with protoplasmic strands radiating out in all directions among the plastids. Granules are present at the bases of the protoplasmic strands close to the nuclear membrane. The nucleus then moves somewhat towards the periphery of the cell and it becomes clear that the protoplasmic strands on that side at least actually extend to the plasma membrane; these strands become arranged in the form of a funnel with the broader end against the plasma membrane. With this stage the zoospore origins clearly exhibit a polar organization.

A circle of granules, which is nearly twice the diameter of the nucleus, now appears where the broader region of the funnel-shaped arrangement of strands meets the plasma membrane. From earlier stages it seems probable that these granules pass along the strands as organized bodies from the neighborhood of the nucleus; they certainly arise within the cytoplasm. The granules in the circle finally fuse with one another to form a firm ring, which lies in the plasma membrane or just under it; this ring is the belpharoplast. The blepharoplast later splits into two rings, one immediately below the other, and the circle of numerous cilia grows out from the lower. The nucleus finally returns to a position near the center of the cell.

The most important points to be noted in this history of the origin of the blepharoplast in Derbesia are as follows. *First,* it seems clear that the nucleus is concerned in a most intimate manner with the development of the blepharoplast, since the numerous granules, which form the ring, appear to come from near the surface of the nucleus and travel along the radiating strands arranged in the form of a funnel; the elements forming the blepharoplast are not developed in the plasma membrane. *Second,* these very numerous granules can not be centrosomes and bear no relation to mitotic figures for there are no nuclear divisions in the sporangium. *Third,* the polar organization of the maturing zoospores does not appear to be present in the

younger stages when the nucleus occupies a central position in the zoospore origin.

Yamanouchi[2] has given an account of spermatogenesis for Nephrodium in one of a series of papers dealing with the life history and apogamy of this fern. The blepharoplasts arise *de novo* just before the last mitosis in the antheridium, that mitosis which differentiates the sperm mother cells. They are first seen as small bodies lying within the cytoplasm on opposite sides of the nucleus and at a considerable distance from it; they appear suddenly, as differentiated by staining, and are unexpectedly large. The blepharoplasts move towards the nucleus and during the final mitosis take positions near the poles of the spindle. Sometimes the blepharoplasts may lie exactly at the poles of the spindle, and consequently suggest relationships to a centrosome, but this is not often, and there can be no such relationship in Nephrodium because centrosomes are not present in the earlier mitoses of the antheridium or at any other period of the life history.

As a result of the final mitosis in the antheridium each sperm mother cell receives one of the two blepharoplasts close by the side of the daughter nucleus. The nucleus in the sperm mother cell now increases in size and the blepharoplast, at first spherical, changes its form. It enlarges and is flattened somewhat against the side of the nucleus and begins to elongate. The outline becomes at first rhomboidal and then band-shaped as the blepharoplast gradually extends around the nucleus in the form of a semi-circular band.

A complicated development follows for both the nucleus and the blepharoplast. One end of the blepharoplast grows wedge-shaped and is loosely applied to the nucleus while the other end remains pointed and extends around in very close contact with its surface. The nucleus meanwhile changes its form, becoming a coiled structure and the elongating blepharoplast follows the coils in the form of a narrow band, which reaches to the end of the nucleus, and finally by extensive lateral growth covers the coil. In this manner the coiled and spiral form of the sperm is developed, and by this time numerous cilia have grown from the surface of the blepharoplast.

There is another structure in the sperm mother cell which

[2] Yamanouchi, Sh. Spermatogenesis, Oogenesis, and Fertilization in Nephrodium. *Bot. Gaz.*, XLV, p. 145, 1908.

must be briefly described. It appears as a minute body in the situation previously occupied by the central spindle of the final mitosis, and consequently far removed from the blepharoplast, which lies near the polar region of the spindle, with the nucleus between them. This structure is the "Nebenkern" of other authors. The "Nebenkern" later occupies various situations in the cell, but always remains as a small structure and does not enter into the construction of the spiral body of the sperm; it finally comes to lie in the cytoplasm which becomes attached, as a vesicle, to the posterior coil of the mature sperm.

Yamanouchi's results on Nephrodium are opposed to those of Belajeff for Marsilia, who holds that the blepharoplasts like centrosomes occupy the poles of the spindle and are derived from centrosomes in a previous mitosis within the antheridium. The account agrees with Webber's conclusions for Zamia that the blepharoplast arises *de novo* in the cytoplasm, and also with Shaw's view for Marsilia that the blepharoplast has no genetic relation to the pole of the spindle in the final mitosis.

It seems probable that the centrosome theory of the blepharoplast, as held by Belajeff, Ikeno and others, has placed undue emphasis on the proximity of the blepharoplasts, in the types studied, to the poles of a closely associated mitosis. There are no mitoses present during the entire period of zoospore formation in Derbesia, which consequently offers important evidence against this view. Since similar conditions are also present during zoospore formation in Œdogonium and a number of other algæ, the investigation of these types is likely to prove very interesting. The blepharoplast unquestionably gives a marked polarity to the cell, but it has not yet been established that this polar organization is derived, as such, from the immediate cell progenitors, however pleasing, for theoretical reasons, would be the establishment of such a history.

BRADLEY M. DAVIS.

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## ORNITHOLOGY

**Riddle on the Genesis of Fault-bars and the Cause of Alternation of Light and Dark Bars in Feathers.**[1]—In a much shorter paper

[1] Riddle, Oscar. The Genesis of Fault-bars in Feathers and the Cause of Alternation of Light and Dark Fundamental Bars. *Biological Bulletin*, Vol. XIV, No. 6, May, 1908, pp. 328–370, pls. xii–xv.

published in February, 1907, under the title "A Study of Fundamental Bars in Feathers" (*Biol. Bull.*, XII, 1907, pp. 165–174) the author gave a résumé of the results of studies here extended and for the first time fully set forth. The existence of "fundamental bars" in feathers was discovered by Whitman in the summer of 1902 (not published till 1907), who found them "to be common to all species of pigeons and birds in general," and that they "appear to mark all feathers of all species of birds."[2] The present research was undertaken at Professor Whitman's suggestion, whose observations furnished the starting point for these studies. These are: "First, there is in all feathers a 'fundamental barring' of the whole length of the feather; second, certain defects (fault-bars) occasionally appear in the plumages of birds reared under adverse conditions." The fault-bars are considered as regards (1) their morphology, (2) their extent and distribution, (3) their cause. Whitman's suggestion that fault-bars are due to malnutrition has been abundantly proved by experimental research. While normally due to lack of nutrition, they may be produced by feeding birds on Sudan III, by mechanical injury of the feather germs, by bad sanitation, parasites, etc., and by the use of amyl nitrite to reduce blood-pressure. From extended observation and experiment it has been determined that "fault-bars are normally laid down at night," when the blood-pressure is normally low. The interrelated facts bearing upon this assumption are thus stated: "(1) Diminished feeding of birds produces emphasized fault-bars. (2) Artificially reduced (amyl nitrite) blood-pressures produce equivalent defects. (3) The fault-bars are produced at night. (5) The lowest daily temperature in birds occurs from 1:00 A.M. to 5:00 A.M. (6) Other physiological conditions of the bird seem to be favorable at night for the production of low blood-pressures. (7) A lowering of the pressure would reduce the food-supply and have a tendency to produce defects."

Those parts of the feather which are grown under the poorest nutritive conditions are the so-called "fault-bars," while the intervening parts—normally the larger—are the result of the highest nutritive conditions, and form the "fundamental bars." The structurally weakened bars are also found to be less pig-

[2] *Bull. Wisconsin Nat. Hist. Soc.*, V, January, 1907, p. 13.

mented, although the difference in this respect between "fault-bars" and "fundamental bars" is not marked, but results in the melanin pigment being "laid down in alternating light and dark transverse bars."

Among the results summarized by the author as confirmed by or resting upon these investigations may be mentioned: The occurrence of fault-bars normally in all birds and in all feathers; they can also be produced experimentally. A daily blood-pressure rhythm with a minimum pressure between 1 and 5 A.M. "The reduced nutrition brought about daily by this minimum blood-pressure; the disadvantageous position, in relation to the blood, of the pigment and barbule elements of the feather; together with the very rapid rate at which feathers grow, furnish the complex of conditions which bring unfailingly into existence a fault-bar, and to a more or less appreciable extent a light fundamental bar, at perfectly regular intervals in the entire length of every feather formation." "The melanin pigment of the feathers of birds shows, under favorable conditions, quantitative variations of the pigment produced in response to changes in the available food supply. This is an additional evidence that this pigment is not a derivative of hæmoglobin, but of the serum or cell proteids." "These results furnish a description, in the terms of physiology, of the mechanism of the 'inheritance' of certain fundamental color-characters of all birds." "The fundamental bars furnish the starting point for all evolutionary studies on the color-characters of birds."

These investigations may well serve as the foundation for researches upon the color-characters of birds, but whether they are to throw much light upon the genesis of color patterns in plumage remains for the future to disclose. It may be noted that no reference is made in this connection to the cause of differentiation of feather structure, treated by the author in a former paper. J. A. A.

## HERPETOLOGY

**Ruthven's Variations and Genetic Relationships of the Garter-snakes.**[1]—This paper of over two hundred pages, devoted to a

[1] Ruthven, Alexander G. Variations and Genetic Relationships of the Garter-snakes. *U. S. National Museum Bulletin* 61, 8vo, pp. xii + 301, with 82 text figures and 1 half-tone plate. Washington, Government Printing Office, 1908.

single genus of snakes, marks a new departure in North American herpetology in respect to methods of procedure. An attempt is made first to determine the value of the characters commonly employed in distinguishing the different forms of the group, as scutellation and color, through study of the normal range of variation in the number of dorsal rows of scales, number and arrangement of the labial and preocular plates, the number of the ventral and subcaudal plates, and the position and color of the stripes. All this is worked out with great care and detail for each form, so far as material is available, which includes about 3,000 specimens, gathered from throughout the known range of the genus. Distinction is made between individual, sexual and geographic variation.

The individual variation in the number of rows of dorsal scales, and the variation in the different forms of the group, is found to be due to the dropping out of certain rows. The law is thus stated: "The individual, geographic and racial variations in the number of dorsal scale rows in the garter-snakes is brought about by the shortening and loss of the same scale rows as are ordinarily dropped posteriorly in conformity with the taper of the body, and there is evidence that this decrease is due to a dwarfing of the body."

The cause of variation in the number of labial plates is not easily explained, but it is believed that there is good reason "for concluding that whatever the factors may be that influence the number of labial plates, the variations are geographic and have been the basis for the racial differences that now exist."

The color pattern in Thamnophis consists of three light longitudinal stripes—a median, and a lateral stripe on each side of the body—on a dark ground. They vary in width in different individuals of the same form, and also more or less in color. The median stripe is the most variable, and in some of the forms it is more or less obsolete. The lateral stripes are constant in position (in reference to the rows of scales involved), and as the position varies in different groups of forms it is available in diagnosis. Simple variation in color, however, has little diagnostic significance, owing to the wide range of individual variation within each form; "and, even when there are well marked geographic differences among forms, those in the same region tend to be similarly colored, as Allen has pointed out a number of times in mammals and birds, so that it is impossible to dis-

tinguish them sharply on this basis." Thus there is "a marked increase in bright colors in the Pacific coast region in Washington, Oregon and British Columbia," and an increase in this same region "in the amount of black pigment at the expense of the paler colors." "A tendency toward a paler ground color and lighter stripes" is noted in western Texas, southern New Mexico, southern Arizona and northern Mexico, and "a tendency toward the production of red pigment on the Great Plains," and "toward dark colors in the forest region of eastern United States."

As a result of these detailed studies of variation and their probable causes and significance, the taxonomy of the group here presented is quite different from that of preceding authors. Only 19 "forms" are here recognized, in place of the 30 currently admitted by herpetologists. The author says:

> "It may seem the extreme of 'lumping,' to assert that there are but four great groups or lines of descent in the garter-snakes, but I believe the evidence is sufficient to warrant the assertion."

These four groups are the *radix, sauritus, elegans* and *sirtalis* groups. He explains in a footnote (p. 39):

> "It is best at the outset to ignore all questions of species and subspecies until their status is established, and to speak of these as forms. Forms, therefore, in the sense employed in this paper, are actual combinations of traits, having geographic extent, irrespective of whether they are isolated (species) or intergrade with their neighbors (subspecies). Detailed discussions of questions of nomenclature are also omitted, although the names are in every case the ones that, in the light of these investigations, we judge to be the right ones, following the International Code of Zoological Nomenclature. The proper name of each form will be found in the footnotes, together with the synonomy."

In the "Table to illustrate the combinations of traits into forms, groups and divisions in the garter-snakes" (pp. 40, 41), the "forms" and "groups," and "primary divisions" (the latter simply numbered I and II) are listed, but it would have been a great convenience if he had given somewhere in his monograph a list of the "forms" with their full names as here employed. The form of nomenclature given in footnotes implies the provisional recognition of 12 species (binomials) and seven additional subspecies (trinomials), as follows:

| | |
|---|---|
| 1. *Thamnophis megalops* (Kennicott). | *Radix* group. |
| 2. *Thamnophis marcianus* (Baird and Girard). | |
| 3. *Thamnophis radix* (Baird and Girard). | |
| 4. *Thamnophis butleri* (Cope). | |
| 5. *Thamnophis sauritus* (Linné). | *Sauritus* group. |
| 5*a*. *Thamnophis sauritus proximus* (Say). | |
| 5*b*. *Thamnophis sauritus sackeni* (Kennicott). | |
| 6. *Thamnophis angustirostris* (Kennicott). | *Elegans* group. |
| 6*a*. *Thamnophis angustirostris melanogaster* (Peters). | |
| 7. *Thamnophis scalaris* (Cope). | |
| 8. *Thamnophis phenax* (Cope). | |
| 9. *Thamnophis hammondi* (Kennicott). | |
| 10. *Thamnophis ordinoides* (Baird and Girard). | |
| 10*a*. *Thamnophis ordinoides elegans* (Baird and Girard). | |
| 11. *Thamnophis eques* (Reuss). | *Sirtalis* group. |
| 11*a*. *Thamnophis eques sumichrasti* (Cope). | |
| 12. *Thamnophis sirtalis* (Linné). | |
| 12*a*. *Thamnophis sirtalis parietalis* (Say). | |
| 12*b*. *Thamnophis sirtalis concinnus* (Hallowell). | |

Of these groups he states (p. 186) that the *sirtalis* group "is without doubt the least diversified," since its members are given by most herpetologists only subspecific rank, owing to their evident intergrading.

Later on in the paper, in his "Discussion of Origins," he gives his reasons for believing that the genus Thamnophis had its origin in northern Mexico, and not in southeastern United States, as held by Cope and Brown. The four "groups" are each represented in northern Mexico and southwestern United States, and "each group is formed of a line of directly related forms, the extremes of which are very distinct," and these lines converge toward northern Mexico. He further states, under "Method of Evolution of the Forms" (p. 192): "If the range of the forms in the different groups of garter-snakes be carefully examined it will be found (1) that the different forms of the same group are found in different geographical regions, characterized by different environmental conditions; (2) that the area along the common boundary of two forms of the same group, where transition in characters takes place, is relatively

narrow''; just as has long been known to be the case in mammals and birds, and as Ortmann has recently affirmed to be the rule in crawfishes.

He considers that

"Experimental work alone can sufficiently reveal the influence of the environment upon the dwarfing and scutellation of these snakes. In the case of the garter-snakes, however, it should be noted: (1) That most of the forms are the result of dwarfing. (2) That the amount of dwarfing does not seem to be directly associated with the nature of the environment, for the form inhabiting a particular region is only slightly different from its nearest neighbor in the same group, while forms of widely different scutellation may inhabit the same region. Thus the conditions which apparently determine the scutellation of any form is the scutellation of its immediate progenitor, and the dwarfing it has itself undergone."

He believes that he is "justified in concluding that the dwarfing is associated in some way with the environment." He then cites Allen's law (1876)[2] that the environmental conditions at the center of origin are most favorable for the existence of any group, and says:

"However this may be, the following facts will stand: (1) That the maximum scutellation and size in the genus Thamnophis occurs at the center of dispersal, and the forms that have been produced in the history of its migration have been formed principally by dwarfing and reduction in scutellation; (2) that the variation in the number of scales in the different series is definite and not promiscuous, and is correlated in a remarkable degree with changes in the environment. The development of the different groups has thus been orthogenetic."

He continues:

"From these facts it seems to me that the most tenable hypothesis of the evolution of the genus Thamnophis is that it originated and became differentiated into four main groups in northern Mexico. From

[2] "In a general way, the correlation of size with geographical distribution may be formulated in the following propositions:

"1. The maximum physical development of the individual is attained where the conditions of environment are most favorable to the life of the species. . . .

"2. The largest species of a group (genus, subfamily, or family, as the case may be) are found where the group to which they severally belong reaches its highest development, or where it has what may be termed its center of distribution. . . ."—*Bull. Geol. and Geograph. Surv. Terr.*, Vol. II, No. 4, p. 310, July 1, 1876.

this region the groups radiated in all directions, but principally to the northward, and wherever they entered different regions the changed environmental conditions acted as an unfavorable stimulus, which retarded growth, and differentiated the groups into dwarfed forms."

The first forty pages of this notable monograph are devoted to the taxonomy, distinctive features, and "variations" of the garter-snakes; the next one hundred and forty to a detailed account of the various "forms," including description, habits and habitat relations, range, variation and affinities; then follow about twenty pages of conclusions and general discussion, a bibliography of about 85 titles, and the index. The eighty-two text illustrations consist of diagrams showing the arrangement of the dorsal scale rows, the head plates, and the arrangement and numerical variation in the labial plates; diagrams illustrating the scale formula and its variations in the different forms; distribution as indicated by locality records (plotted on maps); and habitat views (half tones). It is altogether an excellent piece of work, which we hope to see emulated in other fields of taxonomic research, for which there is ample opportunity in the higher classes of vertebrates.

In his introduction Dr. Ruthven alludes to the "barrenness of general results" that has marked the systematic work in herpetology, due in part to the method employed, which has been "largely analytical in its nature, being for the most part descriptive of the existing diversities." While such work is important, it only makes known present conditions; as the author forcibly says, a knowledge of the processes that have brought them about is of the greater interest, since "systematic work can only become a true science when it seeks to formulate the laws involved in the history of the present forms. After analysis, therefore, as has been said, comes the need of a larger synthesis."

Dr. Ruthven's monograph strongly appeals to the present reviewer for two reasons: First, when curator of reptiles at the Museum of the Boston Society of Natural History some thirty years ago, he spent much time in trying to unravel the intricacies of variation in the garter-snakes, with a view to publication of the results, but other and more pressing interests intercepted the work; secondly, he repeatedly in the early seventies made strong appeals for the synthetic method in systematic work, and has published a large amount of data on individual,

sexual and geographic variation. Forty years ago systematic work was almost wholly analytic, and especially so in respect to the mammals, birds and reptiles of this continent. In my paper "On the Mammals and Winter Birds of East Florida, with an examination of certain assumed specific characters in Birds," etc., published in April, 1871,[3] the conclusions arrived at respecting "species" and specific characters are thus summarized:[4]

"(1) That the majority of nominal species originate in two principal sources of error, namely, (*a*) an imperfect knowledge of the extent and character of individual variation, and (*b*) of geographical variation. (2) That this imperfect knowledge is mainly due to the neglect of zoologists to study with sufficient care the common species of their respective countries, whence has arisen a faulty method of investigation and erroneous ideas respecting species and specific characters. (3) *Instead of the method at present pursued by a large school of descriptive naturalists—the analytic, or the search for differences—being the proper one, that synthesis should be duly combined with analysis, and that general principles should be sought as well as new forms, or so-called 'new species' and 'new genera.'* (4) It is claimed that nothing is to be gained by giving binomial names to climatic or other forms, in cases where, however considerable the differences between them may be, a complete transition from the one to the other can be traced in specimens from intermediate localities, notwithstanding the plea sometimes urged that their use affords 'convenient handles to facts.'"

No 3 of these conclusions,[5] here italicised, denotes the class of research exemplified by Dr. Ruthven's monograph. His method of approach to the problem before him is thus stated:

"Three steps are necessary to determine the genetic relationships and simplify Cope's elaborate arrangement of the group: (1) The value of

[3] *Bull. Mus. Comp. Zool.*, Vol. II, No. 3, pp. 161–450.

[4] *L. c.*, p. 163.

[5] No. 4 may be considered as an entering wedge which led up to the later adoption of trinomials. In 1872 (*Bull. Mus. Comp. Zool.*, Vol. III, No. 6, pp. 119 *et seq.*, July, 1872) varietal names were advocated and systematically adopted for intergrading forms, which were referred to as subspecies or races, the same method of designation being almost simultaneously employed by other American ornithologists and mammalogists. For several years the third term of the name was separated from the second by the interposition of the abbreviation "var.," or by a letter (Roman or Greek, according to the preference of the author); in 1877 and 1878 trinomials, pure and simple, came generally into use in this country for birds and mammals, and soon after for reptiles.

the characters must be determined; (2) geographic probabilities must be utilized; (3) similarities and intergradations must be sought."

As a result the 43 forms (20 species and 23 subspecies) recognized by Cope in his posthumous work "The Crocodilians, Lizards, and Snakes of North America" (Rep. Smiths. Inst., 1898), are reduced to nineteen; and of the twenty-two names given by Cope eighteen appear only as synonyms. Nearly seventy names have been conferred on these nineteen forms, or an average of three and a half for each.

Dr. A. E. Brown, the last preceding reviser of the group, in his "Review of the Genera and Species of American Snakes, north of Mexico," published in 1901,[6] reduced the number of forms to eighteen—ten species and eight subspecies; he proceeding on somewhat the same lines as Ruthven, namely, "that a knowledge of the laws under which forms are developed is to be best gained by a study of variations." While the number of forms admitted by the two authors is practically the same, the taxonomic results are widely diverse.

Dr. Ruthven believes that the garter-snakes will be found to furnish excellent material for experimental research, as they are hardly in captivity, and prolific; and that the first problems to be attacked are the inheritability of scale characters and the influence of inbreeding and unfavorable conditions of food and temperature. But it is to be remembered that experimental research must necessarily be conducted under unnatural conditions, and that the results do not necessarily show what has taken place under natural environments. While the results thus obtained are always interesting and suggestive, they can not be looked upon as conclusive respecting what has actually occurred under natural conditions.

J. A. A.

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## LEPIDOPTERA

**Hybrid Lepidoptera.**—Although published more than a year ago, Mr. J. W. Tutt's account of hybridization and mongrelization in Lepidoptera is probably scarcely known to evolutionists in this country. The two chapters in which he sums up and discusses all that is known on these subjects are prefaced to a much larger work, the first volume of the "Natural History of the British

[6] *Proc. Acad. Nat. Sci. Phila.*, 1901, pp. 10–110.

Alucitides." The book, a large volume of 558 pages, is part of Mr. Tutt's exhaustive "Natural History of the British Lepidoptera," this particular volume dealing with the plume moths. The treatment of the several species is even more exhaustive than that given by Mr. Scudder in his great work on the butterflies of New England; and as in Scudder's work, the purely taxonomic details are relieved by chapters on general topics.

In his two chapters, Mr. Tutt enumerates all the recorded crosses between different species (hybrids) and between different forms of the same species (mongrels), and gives numerous particulars about them. At the end of the book is an appendix describing other cases made known while the volume was in press. It appears that about 90 hybrid Lepidoptera are known, these being especially numerous among the Attacides and Anthrocerides. The well-established hybrids have been reared in captivity, and it is justly argued that many alleged hybrids found at large must be regarded with extreme suspicion, as being quite probably merely variations of one of the supposed parents. The most distantly related species which have, when crossed, produced fertile eggs and subsequent larvæ, are *Saturnia pavonia* × *Graellsia isabellæ;* but in this case the larvæ could not be raised to imagines. There is a very interesting discussion of the question whether hybridization is capable of giving rise to new species in a state of nature. This is considered extremely unlikely, for the following reasons:

"Even when hybridity is not difficult to procure between two species, the progeny shows little fertility *inter se,* and, although the males are more frequently fertile with females of either of the parent species, the female hybrids are much more rarely fertile with the males of the parent species, and at present few hybrids show comparatively free fertility *inter se.* This appears to be largely due to the anatomical and morphological upset in the sexual organs of the female hybrids, an upset that frequently finds its outward recognition in the development of gynandromorphic forms, in which the primary sexual characters are often considerably modified, and correspondingly marked changes take place in the secondary sexual characters.

"Assuming, however, hybridity ever to take place in nature, the hybrids themselves will often, presumably, follow one or other of the parent forms so far as relates to its habits, time of appearance, etc., and the chance of a male and female hybrid,

assuming that some of both sexes get through successfully, then meeting each other, as against the possibility of either meeting and pairing with or being paired with a male or female of the much more abundant parent form, is so remote that one puts aside the possibility."

The instances of mongrelization are classified under the following headings:

1. Crossing of typical form and local race.
2. Crossing of typical form and aberration; production of artificial races by inbreeding.
3. Crossing of typical forms with aberrations tending to develop melanochroic races.
4. Crossing of typical form with aberration trying to set up local race.
5. Crossing of dimorphic forms of a species which occur together and rarely appear to attempt to supplant each other.
6. Crossing of typical forms with possible constitutional aberrations.
7. Dimorphism in one sex.

It is impossible to give any summary of the many cases described under these headings, but enough has been said to show how valuable the work is to students of evolution and variation.

T. D. A. COCKERELL.

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## PARASITOLOGY

**Parasitic Diseases in the Philippines.**—The paramount importance of zooparasitic diseases in the Philippines may be judged from the recently published record of the bureau of health since the medical work at Bilibid Prison was placed under its charge in November, 1905. The prevailing diseases treated in Hospital A, Bilibid Prison, were hookworm, 1,537 cases; amebic dysentery, 551 cases; acute dysentery, 174 cases; cholera, 18 cases; pneumonia, 62 cases; beriberi, 60 cases; conjunctivitis, 221 cases, and malaria, 174 cases; 81 per cent. were thus due to animal parasites. The death rate decreased from 238 per thousand in 1905 to 13.5 per thousand in June, 1907. General sanitary measures were responsible for the first reduction to about 75 per thousand; active measures against animal parasites led to the further reduction.

The establishment of a separate department of medical zoology in the curriculum of the Philippine Islands Medical School is a natural result of the extreme prevalence of animal parasites, and of the diseases to which they give rise. About 80 per cent. of the entire population is infected, or counting different species separately, 200 infections occur to each 100 inhabitants. While the severe results of such infection noted in Porto Rico and elsewhere are not found, yet the population of the Philippines presents a higher percentage of infection with intestinal worms than has ever been definitely reported from any other people and the condition is essentially a chronic one, the results of which manifest themselves indirectly in the general physical impoverishment of the people and the high rate of morbidity and mortality accredited to other diseases.

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## THE PATAGONIAN FAUNA

**Results of the Hamburg Magellan Expedition.**[1]—The importance attaching to a knowledge of the fauna and flora of the southern extreme of South America—especially in connection with the so-called "bipolarity" theories, and with the newly explored Antarctic fauna—has been recently more fully recognized. For a long period this region was neglected. Its great distance from the centers of scientific activity, the inclement climatic conditions, the unfriendly native population, the difficulties of navigation which led every navigator to breathe more freely when he had seen the Magellanic mountains sink below the horizon in his wake—all these factors contributed to the difficulty and cost of scientific exploration, and tended to turn the scale unfavorably, when projects of collecting expeditions were discussed in Europe.

Yet the little that was known hinted of great interest in what remained to be discovered. The surveying expeditions of Fitzroy, King, Wilkes, of Nares and Coppinger, the circumnavigations of U. S. S. *Hassler* and *Albatross*, the work of the *Challenger* and of the French Mission to Cape Horn, in connection with the international polar meteorological stations—each in its turn added something to the sum total of information about these regions. The growth of commerce, with the gradual exploita-

[1] Ergebnisse der Hamburger Magelhaensischen Sammelreise, 1892–93. Herausgegeben vom Naturhistorischen Museum zu Hamburg. Bde. I–III, 1906–7.

tion of the gold-washing and sheep-raising industries of southern Patagonia, made the region more accessible; the increasing use of steam in navigation diminished the terrors of the straits for sailors, and the occasional visits of seal hunters offered opportunities for collection of other than fur animals. Really valuable material obtained for the Hamburg Museum by the merchant captains and officers Ringe, Kophamel and Paessler drew renewed attention to the subject, and projects of systematic exploration were discussed by Dr. von Neumayer and director of the museum Professor Dr. G. Pfeffer.

Times were unfavorable at first, due to civil war and other disturbances in Chile, and it was only in 1892 that it seemed prudent to actually despatch a collector.

The financial question was settled by the generosity of citizens of Hamburg and by grants from various scientific societies of the city, and plans were decided upon under the skillful direction of Dr. Pfeffer. The choice of Dr. W. Michaelsen as explorer and collector proved well advised. He left Hamburg in July, 1892, returning in September, 1893, with an extremely large, valuable and well-preserved collection in all branches; a collection believed to be the largest and most important ever brought from those shores.

Some papers on part of this collection, or partly based upon portions of it, have already appeared in various publications, notably Strebel's work on the mollusca, Michaelsen on the holosomate ascidians, Hartlaub on the hydroids, and Ohlin on the valviferous isopods.

Nearly all the various Antarctic expeditions of the last few years have touched, coming or going, on the Magellanic shores, and much of the zoological material contained in their elaborate reports has been gathered there.

Meanwhile a multitude of specialists have been busy with the Michaelsen material and many of the papers during the last ten years have been separately issued. At the present time these have been brought together, united with others not previously published, and, under the editorship of Dr. Pfeffer, issued by the Hamburg Museum in three portly, beautifully illustrated volumes.

The first volume, which relates to generalities, chordata, echinoderms and cœlenterates, has an historical preface by Neumayer, a brief account of his voyage by Michaelsen, and a

very condensed summary by the editor, in which he points out in what papers the problems of zoogeography are touched upon from the standpoint of the student of special groups, with an intimation of what will be a most welcome general discussion in the future, of those problems from a general and inclusive point of view.

The first paper is by Kustos Paul Matschie, of the Berlin Museum, describes eight species of mammals, of which one, a *Herperomys,* is described as new, and adds a catalogue of mammals of southern South America, which will be found useful, as it is annotated with mention of localities and enumeration of synonyms. As it is obviously impracticable to give within the limits of this review a synopsis of each of the multitude of papers of which these volumes are made up, the reviewer will endeavor to tabulate their contents so that those interested may find an indication of what they contain on each topic. The data on which each paper was originally separately issued are enclosed in parentheses. Each paper is separately paginated, there being no general pagination or plate numeration for the volume as a whole.

VOLUME I

* † Säugetiere. Paul Matschie (1898), pp. 30, pl. 1.
† Vögel. G. H. Martens (1900), pp. 34.
† Reptilien und Batrachier. Franz Werner (1904), pp. 21, pl. 1.
Fische. Einar Lönnberg (1907), pp. 16, pl. 1.
* Tunicaten. W. Michaelsen (1907), pp. 84, pl. 3.
* † Holothurien. H. Ludwig (1898), pp. 98, pl. 3.
* † Echinoideen. Max. Meissner (1900), pp. 18, fig. 1.
* † Crinoideen. H. Ludwig (1899), pp. 7.
* † Ophiuroideen. H. Ludwig (1899), pp. 28.
* † Asteroideen. Max. Meissner (1904), pp. 28, pl. 1.
† Alcyonarien. Walther May (1899), pp. 22, figs. 3.
† Zoantharien. Oskar Carlgren (1898), pp. 48, pl. 1.

* Paper discusses general questions, bipolarity, etc.

† Paper gives a list enumerating all the species of the region known to date.

VOLUME II—*Arthropods.*

* Hemipteren. G. Breddin (1897), pp. 38, pl. 1.
* Aphiden. H. Schouteden (1904), pp. 6.
* Formiciden. A. Forel (1904), pp. 8.
Pteromaliden. Ew. H. Rübsaamen (1902), pp. 8, pl. 1.
† * Coleopteren. H. Kolbe (1907), pp. 125, pl. 3.
* Lepidopteren. O. Staudinger (1899), pp. 118, pl. 1.

* Trichopteren. Georg Ulmer (1904), pp. 26, pl. 2.
Plecopteren. Fr. Klapálek (1904), pp. 14, figs. 10.
Ephemeriden. Georg Ulmer (1904), pp. 8, pl. 1.
* Odonaten. F. Ris (1904), pp. 44, figs. 12.
* † Apterygoten. C. Schäffer (1897), pp. 48, pl. 3.
Arachnoideen. E. Simon (1902), pp. 48.
Gonyleptiden. W. Sörensen (1902), pp. 36.
* Acariden. P. Kramer (1898), pp. 40, pl. 1.
* Pycnogoniden. J. V. Hodgson (1907), pp. 20, figs. 6.
* Myriopoden. C. Graf Attems (1897), pp. 8, figs. 4.
Schizopoden. Carl Zimmer (1907), pp. 6, figs. 17.
* Cumaceen. Carl Zimmer (1902), pp. 18, figs. 31.
* † Cirrepedien. W. Weltner (1898), pp. 16.
* † Süsswasser Ostracoden. W. Vávra (1898), pp. 26, figs. 5.
† Süsswasser Cladoceren. W. Vávra (1900), pp. 26, figs. 7.
* Süsswasser Copepoden. Al. Mrázek (1901), pp. 30, pl. 4.

VOLUME III—*Bryozoen und Würmer.*

* Bryozoen. L. Calvet (1904), pp. 46, pl. 3.
* Gephyreen. W. Fischer (1896), pp. 7.
* Hirudineen. R. Blanchard (1900), pp. 20, pl. 1.
Naiden, Tubificiden und Terricolen. F. E. Beddard (1896), pp. 64, pl. 1.
† Enchytraeiden. H. Ude (1896), pp. 44, pl. 1.
† * Terricolen (Nachtrag). W. Michaelsen (1899), pp. 28.
† * Polychaeten. E. Ehlers (1897), pp. 148, pl. 9.
† * Nemathelminthen. v. Linstow (1896), pp. 22, pl. 1.
* Chaethognathen. O. Steinhaus (1900), pp. 10.
* Nemertinen. O. Bürger (1899), pp. 14.
* Cestoden. Einar Lönnberg (1896), pp. 10, pl. 1.
Trematoden. M. Braun (1896), pp. 8, pl. 1.
Turbellarien:
* Polycladiden. Ritter-Záhony (1907), pp. 20, figs. 9, pl. 1.
Rhabdocoeliden und Tricladiden. L. Böhmig (1902), pp. 30, pl. 2.

The above summary is sufficient to show that these volumes form a library on the Patagonian fauna which will be indispensable to the student of the zoology of the southern hemisphere. Almost without exception the papers conclude with a full bibliography of the subject of which they treat. We hope that the concluding volume of the series which will contain the editor's general discussion will be also provided with a chart, if possible also bearing the bathymetric lines which indicate in a general way the topography of the sea bottom.

WM. H. DALL.

## COLOR NOMENCLATURE FOR NATURALISTS

**A Code of Colors for Naturalists.**[1]—In 1905 Dr. R. M. Strong called attention in *Science* (Vol. XXI, pp. 267–268) to the availability for naturalists' use of the Bradley Educational Colored Papers. Little books containing about 165 samples of these papers may be had for five cents from dealers in kindergarten supplies. Since Ridgway's "A Nomenclature of Colors for Naturalists" went out of print, there has been no convenient and rapid means of designating colors with precision other than by the use of the Bradley papers.

The present work attempts to furnish to all who have to designate colors with precision a simple, practical and unmistakable means of indicating them. This is accomplished by supplying, at a low price, a book of convenient size for the pocket in which are contained a sufficient number of samples of different colors arranged in accordance with a recognized scientific plan and prepared with materials as durable as our knowledge of chemistry permits. All names of colors are rejected except those of the six spectral colors, red, orange, yellow, green, blue and violet. Thus is avoided the confusion inseparable from the use of names for colors. The scheme includes 24 "pure" colors, the six colors of the spectrum named above; six other colors obtained by combining the adjacent spectral colors to produce intermediate colors called red-orange, orange-yellow, yellow-green, green-blue, blue-violet and violet-red; and twelve other colors intermediate between the twelve above named. Thus between red and red-orange there intervenes a lighter red, between red-orange and orange a lighter red-orange, so that the order of the twenty-four colors is as follows: red, red, red-orange, red-orange, orange, orange, orange-yellow, orange-yellow, yellow, yellow, etc. Each color is intermediate between that which precedes and that which follows it. Each of the twenty-four pure colors is made the basis of a double page of samples, on which it appears along with twenty-nine tints, shades and broken colors produced by mixing the pure color with white, black or gray. Twenty-four of these tints and shades and broken colors, in which the white and black are

[1] Klincksieck, Paul, et Valette, Th. Code des Couleurs à l'usage des Naturalistes, Artistes, Commerçants et Industriels, 720 Échantillons de Couleurs classés d'après la méthode Chevreul simplifiée. Paris, 1908; 1 vol., 86 pp., 4¾ x 7½ in. 48 pages contain 720 samples of colors.

used in definite proportions, are numbered consecutively with the pure color from which they are derived, so that the first double page of samples contains reds numbered from 1 to 25, the second reds numbered from 26 to 50, the third red-oranges from 51 to 75, the fourth red-oranges from 76 to 100. Thus the first 100 numbers are given up to red (including red-orange), the numbers from 101 to 200 indicate oranges (including orange-yellow), and so on through the spectrum, until the numbers 501 to 600 indicate violet (including violet-red). In addition to the six hundred colors thus numbered consecutively, there are 120 others, five on each page, all made by adding white to the pure color or to one of the broken colors and all designated by prefixing letters to the numbers on the same page. Thus the number of colors is brought up to 720.

To designate a color it is only necessary to refer to it by its code number. Thus a naturalist may describe the color of a bird as C. C. 120 (C. C. as an abbreviation for Code des Couleurs), and one reading his description knows at once, since the number falls in the second hundred, that the color is a broken orange and by turning to his code has the color itself before him. The naturalist may carry the book into the field and on a pencil sketch may enter the numbers of the colors of natural objects, and from such notes may, at his leisure, prepare colored figures of such objects, long after the objects themselves have faded. Thus there is provided an international code of colors which may be used like a telegraphic code and by means of which men of different nations and professions may intercommunicate without risk of being misunderstood.

The scheme adopted in the code is a simplification of that used in the dye works at Gobelin and elaborated by the chemist Chevréul formerly in charge of the dye works. The simplification consists in reducing the number of pure colors from 72 to 24, in greatly reducing the number of tints and shades and broken colors, and in omitting the grays. The omission of the grays is justified on the ground that all grays are in nature impure, and are therefore represented in the "Code" by shades or broken colors. The Chevréul scheme contains 14,421 colors, including grays, while the "Code" contains but 720, excluding grays. The colors given in the "Code" are, however, so close together that only the trained expert will be able to discriminate intermediate colors; they are probably sufficient for all practical

purposes. They are between 4 and 5 times as many as in the Bradley papers, which have also been arranged in accordance with the scheme of Chevréul (Milton Bradley, Elementary Color).

M. Th. Valette, chemist of the government tapestry works at Gobelin, has selected the pigments used with special reference to their durability. The pigments have been applied to paper without the use of oil as a vehicle, so that their durability is thereby increased. The colored paper has been coated with an insoluble gelatin to protect it from the action of water. The paper thus prepared has been cut into samples 20 by 25 mm., and these have been pasted to the pages of the "Code." The book, thus prepared, seems to answer the needs of naturalists far better than any other practicable scheme, and its use should greatly lessen the growing confusion which has resulted from attempts to designate colors by names without any standard of reference. The writer has tested the book in the field with satisfactory results. While not all colors may be matched by it, the results are accurate enough for practical uses, and greater accuracy is at present to be had only by the use of the color wheel.

JACOB REIGHARD.

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